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14 YEARS OF RESONANCE ON VANGUARD ORBITS

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C. A. Wagner

ABSTRACT

From their establishment in 1959, the orbits of Vanguard 3 (1959-7A) and Vanguard 2 Rocket (1959-2B) have been slowly contracting through at least five strong resonances of 11th order. Tracking with Baker-Nunn cameras and the U. S. Navy's Space Surveillance (radio interferometer) System over a 14 year period has revealed resonant fluctuations on them of up to 0.035° in inclination (peak to peak). Six geopotential terms (lumped coefficients) of 11th order and three of 22nd order have been measured using orbit inclinations derived from this tracking record. The terms of 11th order are significantly smaller than Kaula's rule. (The lumped coefficients are sensitive to geopotential effects as high as 37th degree.) These observed terms are compatible with a recent 27-satellite geopotential solution whose formal coefficient errors are increased by a factor of 3.3.

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14 YEARS OF RESONANCE ON VANGUARD ORBITS

INTRODUCTION

The subject of orbital resonance with the geopotential continues to be of interest to theoreticians [Romanowicz, 1975; Garfinkel, 1974; Allan, 1973] and practical geodesists [King Hele et. al., 1975; Wagner, 1974]. While Garfinkel has solved the problem of resonance with a single geopotential term (or rather, frequency) no one has yet demonstrated a general solution with mixed (nearby) frequencies. Allan has solved the useful case of inclination resonance under constant drag. The features of this solution were recognized by Gooding, 1971, King Hele, 1972, and Wagner, 1973, and applied by them to 15th and 11th order commensurate orbits. The influence of drag on the resonances of the node and perigee can also be observed on decaying orbits [King Hele and Winterbottom, 1974] but as yet has no theoretical explanation.

In spite of theoretical difficulties, much progress has already been made with semi-numerical approaches. King Hele et al., 1975 has observed 11 lumped coefficients of 15th order (odd degree) from many distinct (low eccentricity) orbits contracting through commensurabilities. For these one inclination resonance dominates and, since the error from drag uncertainty has small effect on the orbit inclination, the values given are fairly secure. Less secure are values of even degree 15th order terms derived for six (low eccentricity) decaying orbits from the resonance in the eccentricity (King-Hele et. al., 1974).

Fortunately, for orbits of moderate eccentricity, the so called "fringe resonances" in the inclination can be as strong as the dominant "central" effect (Allan, 1973, p. 224). Observing the decay through resonance of such orbits is especially fruitful. In these orbits the eccentricity variation does not have to be relied upon to define the even degree harmonics of the resonant order. The orbits of Vanguard 3 and Vanguard 2 Rocket ($I = 33°$, $e = .19$, $n = 11$ rev's./day) offer striking demonstrations of this richness (Figures 1 and 2).

Previously, Wagner, 1973 had observed the strong commensurability on Vanguard 3's orbit in 1961-1964. This was one of the fringe resonances prior to the central passage. In the present report the evolution of the inclination of the Vanguard 3 orbit is analyzed over 14 years from launch. The Vanguard 2 Rocket's orbit is analysed only since 1966 when adequate observations were available. Here only 3 resonance passes have been observed, confirming and strengthening the solution for (almost) the same terms observed on Vanguard 3.

DATA

The data actually analysed were mean Kepler orbit elements calculated from independent "weekly" arcs of optical and interferometric angle measurements. The optical measurements (on Vanguard 3, from 1960 to 1965) were precisely reduced from Baker-Nunn camera observations. Osculating orbit elements in this period were then calculated by fitting a precise trajectory through these observations with the Geodyne Orbit Determination System [Lerch et. al., 1974]. Mean elements were calculated from the osculating values by subtracting the short period perturbations from J_2 to J_5 as given by Brouwer, 1959. Mean elements from field reduced Baker-Nunn observations [Miller, 1968a, 1968b] were also examined on Vanguard 3 in 1964-1966. These proved of poor quality and were not used to calculate the lumped coefficients. However, they are compatible with the resonant solution and provide continuity to the Vanguard 3 record (Figure 1).

From 1966, mean elements from the U. S. Navy's Space Surveillance system were used for both Vanguard orbits [Robert Cote and Richard Smith, Private Communication, 1974]. These are elements fit to radio interferometric data by an orbit theory essentially due to Brouwer, 1959. The measurements are direction cosines of the reflected signal from each satellite crossing of a high power radar fence that spans the U. S. at about 30° latitude. Directions from one to six stations near the fence are obtained from each crossing. Prior to May 10, 1971 the Brouwer, 1959 theory with J_2 to J_4 only (and secular terms for drag) was used in deriving the elements.

The long period terms (in the argument of perigee) were added to these doubly averaged elements [Brouwer, 1959, p. 394-395, and Kozai, 1959, p. 371] to produce "observations" easily compared to calculations from mean element integrations [Wagner et. al., 1974]. There is some uncertainty in the oblateness coefficients used in the Navy calculations prior to May 10, 1971 (41087 MJD). This uncertainty contributes to the poorer data "fit" (within the Navy record) in Figures 1 and 2 prior to this date. Of equal importance, however, is the inclusion in the Navy calculations after this date of geopotential effects through (3, 3), and improved zonal values (J_2 - J_5). On the other hand, special '10 day' mean elements were derived for 1966-1970 with the current Navy orbit reduction program. While this data proved superior to the old values, comparison with computations (residuals) were still not as good as in the period after 1971 (using routine elements). The full Vanguard mean element record (after the preprocessing described, but excluding the elements from field reduced observations) is presented in Table 1.

ANALYSIS

The analysis of the Vanguard mean element observations, with emphasis on the inclination data, followed Wagner, 1973. The observed elements were compared to values calculated from a (semi-numerical) mean element trajectory program which selects only long period and secular effects for integration (Wagner et. al., 1974). This program includes direct and indirect (tidal) gravitational terms from the sun and moon, the effects of radiation pressure and atmospheric drag. Capability exists for determining additional (arbitrary) secular terms for the elements.

The development of the geopotential follows Kaula, 1966. The characteristic frequencies of the gravitational perturbations are written as:

$$\dot{\psi}_{m,q,k} = - \dot{\omega} q + k(\dot{\omega} + \dot{M}) + m(\dot{\Omega} - \dot{\theta}_e), \tag{1}$$

where ω, M, and Ω are the argument of perigee, mean anomaly and right ascension of the node of the orbit and θ_e is the Greenwich hour angle. Small m is the geopotential order, q is an eccentricity index (integer) in Kaula's development (the amplitudes of terms are, in general, of order $e^{|q|}$). Small k is another integer combining q, the geopotential degree (ℓ) and an index of the orbit inclination ($k = \ell - 2p + q$, $0 \leq p \leq \ell$). Since $\dot{\omega}$ and $\dot{\Omega}$ are small compared to $\dot{M}$ and $\dot{\theta}_e$, resonance occurs ($\dot{\psi} = 0$) near $\dot{M} = m/k$ (rev's/day). The lowest order resonances for a given orbit then will be $m \approx \dot{M}$(rev's/day) for which k = 1. Small q characterizes the "fine" splitting of the frequencies (or fringe resonances) about the central (generally dominant) one (m, q, k) = m, 0, k.

Broad resonant families are characterized by the rational fraction m/k reduced to it's lowest common denominator r_1/r_2. For a perfectly commensurate orbit ($\psi = 0$), r_2 is the repetition time of the ground trace in days. The strongest resonances are those with one day repetition periods since for these m can be minimum for a given orbit or range of near earth orbits. Calling these minimum m's of a resonant family m_1 (associated with $k = 1$), the resonant species are characterized by the k's, where $m_k = km_1$, $k = 1, 2, 3, \ldots$. Further, the resonant member of a species is characterized by q. Thus, in terms of the 'dominant' member of a resonant family (lowest m, central frequency $q = 0$), the frequency of all other members are given by:

$$\dot{\psi}_{m,q,k} = k\dot{\psi}_{m_1,0,1} - q\dot{\omega}. \tag{2}$$

For the Vanguard orbits, $m_1 = 11$ and the measurable members of this fundamental species were $q = -3, \pm 2, \pm 1$ and $q = 0$. The second species of the orbit ($k = 2$, $m = 22$) was also (barely) measurable including members $q = 0, \pm 1$. But this species was expected to have significantly diminished effects compared to the fundamental. Its passage through resonance was twice as fast as the fundamental's. Also, the critical resonating terms have (roughly) twice the degree and suffer greater loss from both the potential reduction with altitude and the expected reduction of the coefficients themselves ($\approx 10^{-5}/\ell^2$ rms for normalized values).

In addition to these factors, I expected the eccentricity effect to allow, at best, only the central and first fringes of this second resonant species to be measured. As it happened, these resonances for both Vanguard orbits occured in the late 1960's near the height of the solar cycle. As Figure 3 shows, there was higher satellite drag at this time (due to an expanded sun driven atmosphere). Even quicker resonance passages hurt still further the chances of seeing any 22nd order terms.

Two years ago, after observing the strong resonance from the m, q = 11, -2 term on Vanguard 3 I calculated part of Table 2 to try and estimate the observability of the other promising 11th order resonances. This was before I knew of the availability of the excellent NAVSPASUR data. The resonance times (in Table 2) were easy to estimate from mean motions available in otherwise less reliable North American Air Defense Command Space Data elements (see also Figure 3). Allan, 1973 had shown that the excursion of the inclination through a commensurability controlled by drag was proportional to the time of the passage as well as the amplitude of the lumped geopotential coefficient. The actual excursion could only be predicted to within a factor of about 2 since is also depended critically on the phase of the resonant longitude ψ at $\dot{\psi} = 0$. Drag undertainty alone would make this value a random number in a short time for close satellites.

An estimate of the relative amplitudes of the lumped coefficients for the members (q) of m = 11 was first obtained. For a specific Vanguard orbit the amplitudes of all relevant first order perturbations of the inclination to high degree was calculated [Kaula, 1966, p. 40] assuming $J_{\ell m}$ (fully normalized) = $\sqrt{2} \cdot 10^{-5}/\ell^2$. The root sum of squares of these effects (for each q) is listed in Table 2, Row 1. Since the first order variations are inversely proportional to frequency, they were scaled to the same (100 day) period to judge their relative strength (Table 2, row 2).

Allan, 1973, p. 224 had predicted on the basis of the other factors of the geopotential's eccentricity function, that the first fringe resonances would be actually of order 10 e and not just e^1. If the factors of the higher fringe terms grew proportionately, the orbit of Vanguard might be expected to change radically in a slow decay through many resonances (King-Hele, Private Conversation, 1974). But Table 2, Row (2) showed that the expected fringe effects (considering only the geopotential) were not twice (10 × 0.19) the central one but somewhat less. On the other hand their strength might be considerably more than 0.19 of the central's. Taking into account the time through the resonance, I estimated (Row (5)) that the q = -1 and 0 fluctuations would be about as strong as that for q = -2; the q = 1, 2 and 3 effects somewhat weaker. It turned out that these predictions were fairly accurate (compare Row (7) with (5)). Of course the q = 3 effect has yet to be seen, but it should be observable with the 0.001° NAVSPASUR data. Just as the q = -2 term was enhanced by its (chance) occurence in the middle of the solar cycle low in the mid 1960's, so the q = 3 resonance will benefit by the low of the mid 1970's.

Only part of the difference between observation and prediction is explainable by the measured lumped coefficients (compare rows (5), (7) and (9)). The remaining discrepancy must be due to the phase of $\psi_{11,q}$ at commensurability.

A similar analysis was carried out for the nearby orbit of Vanguard 2 Rocket (1959-2B). It predicted significant q = -1, 0 and 1 effects. The NAVSPASUR data (Figure 2) confirms this (for q = 0, and 1). Unfortunately, no good data exists prior to 1966 that shows the full (slowly developing) q = -1 effect. But this resonance appears to be adequately determined from the orbit of Vanguard 3.

The example of one orbit does not prove that King Hele's conjecture (catastrophe) is false. But the expected (relative) strengths of the terms for Vanguard certainly showed no sign of increasing with increasing $|q|$. What they might do for other (e. g. more eccentric) orbits is an open question.

Orbit and Geopotential Determinations

A large number of numerically computed mean element trajectories were "fitted" to the "observed" data in Table 1. The object was to determine the effects of resonance on these orbits, especially in the inclination. All of the computed orbits included the empirical determination of at least six initial Kepler elements, a drag and radiation pressure parameter and a polynomial in the mean anomaly. This last was necessary to keep the phase of the resonant longitudes (ψ) within reasonable bounds over long arcs in the presence of atmospheric model error. Included in all trajectories was the long period and secular part of the zonal geopotential from the Smithsonian Standard Earth 2 [Gaposhkin and Lambeck, 1970]. Also included were the major, direct secular and long period perturbations due the sun's and moon's gravity and the short (182 day) period effects from the sun's potential. Including the short period (14 day) terms in the moon's longitude generally degraded the results because the "observations" were mean values over at least 7 days. Thus they only partly reflect most of these terms. For most of the "observations" that part is a smoothing to less than half, making a poor comparison with the full perturbation.

The data in Table 1 was first analyzed in 10 "arcs" of about 1000 days each, limited by the control of the orbit's longitude. The first row in Table 3 shows the results (inclination residuals) for these arcs where the computed orbits had no resonant effects. The resonant variations in successive (multi-arc) runs were modeled by single terms (ℓ, m): (17, 11) for q = -2, (18, 11) for q = -1, (19, 11) for q = 0, (20, 11) for q = 1, (21, 11) for q = 2, (22, 11) for q = -3, (22, 22) for q = 0, (23, 22) for q = -1, and (25, 22) for q = 1.

The orbits of Vanguard 3 and 2 Rocket body actually differ enough (see Table 1) that, theoretically they will see different lumped coefficients. The difference though amounts to only about 2×10^{-9} which is at the level of precision of the best observed terms. Considering the overall variability of the solution due to correlation and possible biases, only a single term per frequency was chosen for the multi-arc solutions.

It should be noted that arc 9 covers the same interferometer tracking data as arcs 3 and 4 and arc 10, arcs 7 and 8. While the reprocessed data arcs (9 & 10) showed significantly smaller residuals than the old one's, the comparisons with computations still contained unresolved systematic errors. These are discussed below. Since these errors have not been resolved, the old data arcs were retained so as not to prejudice the solution.

Row 2 (Table 3) shows the results from a preliminary solution for the 4 strongest frequencies. Row 3 shows the same solution with improved data editing, a better (empirical) fit to the semimajor axis and mean anomaly data and greater weight to the (better) inclination data in arcs 9 and 10. Row 4 shows the effect of adding the q = 2 frequency as well as solving for a single odd zonal harmonic to absorb error in this part of the SAO SE 2 model.

Individual arc analyses showed that even after a reasonable empirical adjustment of ℓ, m = (3, 0), significant residuals were seen in the Navy data with a period of about $2\pi/\dot{\omega}$ (75 days). Examination of Figures 1 and 2 also shows that the "wings" of the resonance passes are not fit as well as the central portions. The residual oscillations in the wings actually appear to have frequencies closer to $\dot{\psi}$ than $\dot{\omega}$. King Hele, 1975 noted this characteristic anomaly with Ariel 3. Some of this effect is relieved when the higher species of the resonant family (k = 2, 3, ...) are included. These tend to participate more strongly in the central portions ($\dot{\psi} \sim 0$) than in the wings where their frequencies are multiples of the dominant species (k = 1). But even with 22nd order terms the anomaly persists, suggesting the presence of data biases associated with the tracking model.

Two such bias sources immediately suggest themselves. The first is geometric, arising from inadequate station positions, refraction model or angle calibrations. For example, a 0.001° inclination shift could result from a 111 m latitude error in a station coordinate. An error inherent in the tracking geometry would tend to have a frequency $\dot{\psi}$, since $\dot{\psi}$ is associated with repetitions of the trace of the orbit (Allan, 1973, p. 223). The second cause is dynamic; the neglect of critical geopotential orbit perturbations in the tracking model. Almost certainly this bias is present in the "old Navy" data (arcs 3, 4, 6 and 7). The evidence is in the reduced "residuals" for arcs 9 and 10 as mentioned earlier. But the data in arcs 9 and 10 have significantly poorer comparisons with long term computations than that in arcs 5 and 8 which use the same dynamic model. The characteristic "wing" anomalies are still seen (at a reduced level) in analysis of arc 9 and 10 data. The reason they appear (almost) absent in arcs 5 & 8 may be because the "shifts" through commensurability in these arcs are small or almost absent. In this circumstance, the resonant variations (being almost uniformly sinusoidal) could absorb much of the geometric bias. Arc 5 (Vanguard 2R) with almost no shift shows smaller residuals than arc 8 (Vanguard 3) which has a small but significant step through commensurability. Yet the geometric circumstances of these (same) resonances (the history of $\psi_{11,2}$) are different as witness the different character of the variations. But (as will be seen) the (11, 2) resonance terms for these two orbits (separately determined) are fairly compatible. Therefore, it would seem the role of geometric bias is minor in arcs 5 & 8 though I cannot be sure of this without a thorough error analysis. If this is the correct conclusion and if dynamic bias is also small here then why is bias (geometric or dynamic) more of a factor in arcs 9 & 10; our original question. Again, only a thorough error analysis can answer it. However, the agreement of separate solutions for the resonances on the two orbits suggests that the final multi-arc result is reliable in spite of these unanswered questions.

Returning to the analysis of the multi-arc solution (Table 3) the arc 3 residuals (from the solution in row 4) showed an unresolved "shift" suggesting the effects of 22nd order terms. Adding m, q = 22, 0 to the solution produced the marginally better results in row 5. Adding m, q = 22, 1 and 22, -1 (row 6) significantly improved residuals in arcs 3 and 9 for the Vanguard Rocket orbit. However, some moderate correlations between 22nd and 11th order terms were introduced. The final solution using all the data (inclination emphasized) included the minor (11, -3) resonance on Vanguard 3 in 1960 (row 7). While the determination of (11, -3) was weak, the bounds were interesting. As will be seen, they showed a result significantly smaller than predicted by Kaula's rule.

Finally a solution was made using the inclination data only (row 8) which differed little from the one before. (This is the preferred solution, labeled "observed" in Table 4). In fact the whole series of solutions showed remarkable consistency (Figure 4). Other solutions were made using the data in selected arcs (Figure 5). These showed more scatter but are also consistent. Combining the data for both orbits has undoubtedly strengthened the reliability of the determination by helping to overcome the biases peculiar to each orbit and data set.

Lumped Coefficients

Following Gooding, 1971 lumped coefficients were derived from the rates of the inclination variation for each resonant term, using Kaula's (1966) development of the geopotential. For a given resonant member (m, q), the linear combination of resonant rates are:

$$\dot{I}_{m,q} = \left[\sum_{\ell} C_{\ell,m} f_{\ell,m,p,q}\right] \sin \psi_{m,q}$$

$$+ \left[\sum_{\ell} S_{\ell,m} f'_{\ell,m,p,q}\right] \cos \psi_{m,q}, \tag{3}$$

where $f' = \pm f$ depending on the parity of ℓ. In either case it is seen that the sine and cosine terms in $\psi_{m,q}$ are essentially determined by two lumped coefficients

$$(C^*, S^*) = \sum_{\ell} Q_{\ell} (C_{\ell,m}, S_{\ell,m}) . \tag{4}$$

The influence factors Q depend on f and for the Vanguard resonances (in terms of fully normalized coefficients) are displayed in Table 4. (The Q's originally were scaled perturbations. They have been normalized to the term with the largest effect). Figures 4, 5 and 6 present the Vanguard solutions in terms of these lumped coefficients.

An important computation is the expected value (E) of the square of the lumped coefficient since it can be used as a check on the proper scale for the actual geopotential terms. Thus if the geopotential terms are independent and randomly distributed with zero mean;

$$E[(C^*)^2, (S^*)^2] = [\Sigma Q^2 E(C^2), \Sigma Q^2 E(S^2)] .$$

Assuming Kaula's rule ($10^{-5}/\ell^2$) for E (C^2) and E (S^2), the expected truncation effect in C* and S* and the total term has been estimated (in Table 5). Using;

$$\sigma(C^*,\ S^*) = [(E(C^*)^2)^{1/2},\ (E(S^*)^2)^{1/2}]\,, \tag{5}$$

the expected amplitude of a lumped harmonic (C*, S*) is just:

$$\sigma_A = [\sigma^2 C^* + \sigma^2 S^*]^{1/2}.$$

All the solutions in table 5 are given as lumped coefficients.

Figure 6 shows that the 11th order terms from the Vanguard resonance are significantly less than Kaula's rule (as a set). On the other hand (Figure 4a) the 22nd order terms are somewhat greater than expected by the rule (but less reliable with larger standard errors).

Solution Correlation

A number of factors tend to introduce correlation into the solution, which while not severe, are still significant and explain some of the variability of the results. The full correlation matrix for the preferred solution (Table 5) is given in Table 6. The principle cause for correlation between $C^*_{m,q}$ and $S^*_{m,q}$ is that the resonant longitude ψ is not sampled uniformly. Where $\dot{\psi} \sim 0$ a small range of ψ is heavily sampled and the sensitivity of the perturbations to the resonant coefficients is great. Away from commensurability ψ is more uniformly sampled but the sensitivity is smaller. Cross correlations while smaller are not zero because the separation of resonant members is not perfect, in spite of the segregation of frequencies. Part of the problem is data distribution; too little data determining too many effects. The central 22nd order resonances occured around the solar cycle high. They came and went too quickly to be well discriminated from the central 11th order effects. The central members (11, 0) and (22, 0) always tend to be correlated since they are commensurate at the same time. The different wing frequencies help to discriminate these species but, as Table 6 shows these still give the highest cross correlations. The effects of the highest correlations, for (11, -1) and (11, 2), are shown by the rotated (1σ) error ellipses in Figures 4a and 5. More of the variability of the results are (indeed) accommodated considering these correlations.

Comparison with Gravity Models

The results of the Vanguard resonances observed lumped coefficients) can be directly compared to computed values from gravity models using equation (4). I have chosen 5 representative gravity fields for this comparison, 2 satellite data-only fields and 3 combination fields with surface gravity data. PGS 162 is a Goddard Space Flight Center solution (F. J. Lerch, Private Communication, 1975) using optical and electronic (Laser, Doppler, C Band and S Band radar and Minitrack) data on 27 orbits. The 11th order coefficients in this field (to 19, 11) stem almost entirely from the optical data on the Vanguard 2 rocket and Vanguard 3 orbits. PGS 162 employs numerical integration (in 7 day arcs) to compute the trajectories. The SAO-69 B6.1 is the last available Smithsonian Astrophysical Observatory Satellite field using optical and laser data only (E. M. Gaposchkin, Private Communication, 1969) and the same Vanguard orbits as PGS 162. The 11th order information in this field extends to only 16th degree. The orbits in this solution are computed analytically. The SAO SE 3 [Gaposchkin, 1974], complete to (18, 18) combines surface gravimeter with satellite optical and laser data. But it retains (essentially) only the Vanguard 2 orbit (in shallow resonance) for satellite geopotential information on 11th order terms. The WGS 72 field (L. Decker, Private Communication, 1974) is a U. S. Defense Department solution combining satellite optical, doppler, laser and secor data on more than 30 orbits with surface gravimeter and astrogeodetic observations. The 11th order satellite information is the same as in SAO 69 B6.1, extending to (16, 11) on the three Vanguard orbits. However, the surface gravity information extends to (19, 11). The results of these calculations are listed in Table 5 and displayed in Figure 6.

Referring to Figure 6, the results for the 11th order terms are significantly less than Kaula's rule, the sensitivity of the lumped coefficients going as high as 37th degree. No current gravity model includes 22nd order terms, whose effect on the lumped coefficients is expected to be significant to as high as 41st degree.

In general it is seen that excepting SAO SE 3, the gravity models overall compare about the same to the observations of these resonances. The SAO SE 3 is distinctly poorer in this comparison. The (11, -3) result is especially striking. In spite of the weak observation of this effect, it clearly discriminates between the SAO SE 3 and the other model "predictions". The reason for the anomalous SAO SE 3 result may be simply that the surface gravity influence is too great on the solution. By eliminating the deep resonant Vanguard 3 and 2 rocket orbits (from the geopotential solution), there are no problems of very small divisors in SAO SE 3 compared to 69-B6.1. Yet the results are worse for SAO SE 3. It would be helpful to have a satellite-only solution (analytic or numeric) excluding the deep resonant orbits. I suspect that such a solution would agree best with these observations. But good surface gravity information at full weight can have excellent results, as shown by PGS-63. This field (F. Lerch, Private Communications, 1974) has the same satellite information as PGS 162 but to 25th degree in 11th order terms. Surface gravimeter data ($5° \times 5°$ means) to (25, 25) is included in this model. This model actually agrees best with these observations overall. It is significantly better for the (11, 0) (11, 1) and (11, 2) resonances.

A valuable use for these observations is in calibrating the errors in current geopotential models. The satellite solutions for 11th order terms such as PGS 162, contain deep resonant Vanguard information analysed over short arcs (1 - 4 weeks). A numerical solution such as PGS 162 (with 1 week arcs) will have difficulty distinguishing a long term resonant effect from a simple orbit parameter shift which is also part of the solution. Such 'fields' can be expected to have poor 11th order terms.

A 'calibration' of the PGS-162 solution using these well observed resonances shows that its agreement with them is almost as expected from the average agreement of PGS 162 with global surface gravity data.

Calibration of PGS 162 11th Order Terms

The compatibility of a set of calculated values (C) (such as the lumped coefficients of PGS 162) with observed quantities (O) can only be judged (with precision) in terms of an error model for both. Figure 6 certainly suggests that PGS 162 is compatible with these observations. In fact the raw correlation coefficient ($\Sigma\, OC/[\Sigma\ O^2\ \ \Sigma\, C^2]^{1/2}$) between the computed and observed quantities is 0.88. (The most agreeable set of computed quantities is PGS 63 for which this coefficient is 0.96.) But the precise question is how good is this agreement in terms of the expected errors in the observations and the calculated quantities.

Let a (column) vector of observed values O have errors ΔO. Similarly a set of calculated values C has formal errors of commission, Δ C, and errors of omission (or truncation), ΔT. The errors of comission are exactly calculable from the formal errors σ of the model coefficients. The errors of omission, ΔT can only be estimated from expectations of the effects of terms not included (assumed to be zero) in the (calculated) model. There is an innocent assumption here that these omitted geopotential terms are necessary in calculating the lumped coefficients. If the resonances were merely reobserved, the model needs only a single geopotential term for each. Then, if the model has the required number of terms (six total here, 3 odd and 3 even of 11th order) the infinite number of 'omitted' terms in the lumped coefficients (equations (4)) can be ignored. The question is not academic for PGS 162 which includes terms to only (19, 11). At this degree the simple estimate of truncation error (assuming the model has not observed the terms) dominates the other errors (see Tables 5 and 7). But the 11th order coefficients in PGS 162 must be determined almost entirely from the Vanguard optical observations. (On these orbits the 11th order perturbations are strongest, by far). Furthermore, analysis of the perturbations shows the information is mostly along-track, from the resonance in the orbit's 'energy'. But the geopotential variations of the inclination are predictable from the measured variations in the 'energy' (Kaula, 1966, p. 40, Wagner and Klosko, unpublished, 1975). Therefore I have assumed initially that these resonant Vanguard frequencies have already been measured (by the raw tracking data) in PGS 162. I assume that the burden of the Vanguard residuals (observed minus computed lumped coefficients) is taken up only in the observation errors and the errors of commission (Table 7).

A second calculation has also been made using an estimate of the truncation error derived from 2 unpublished satellite models (J. A. Richardson and J. E. Brownd, Private Communication, 1975). The truncation point was the only difference in these models (for 11th order terms). One half the difference in the lumped coefficients computed from these models, one truncated at 17th, the other at 19th degree, was taken as an estimate of ΔT (Table 7). This estimate is more realistic than that from Kaula's rule but is not perfect since no model is available with truncation above degree 19.

The residual vector for all observations is then:

$$O - C = \Delta O + \Delta C + \Delta T \tag{6}$$

where the errors ΔT are the most difficult to assess. It is assumed that the errors for each observation are random, uncorrelated, and the expected value (E) of each residual is zero. The expected truncation error is zero because the expected value of an omitted (unknown) harmonic term is zero. But the errors ΔO (and ΔC) are not uncorrelated among different observations. This is clear from the correlation matrix for both the 'observations' and the calculated values (Table 6). (The calculated values are actually somewhat more correlated because the Vanguard data distribution in PGS 162 is weak.) One but not both of these correlated sets of errors can be eliminated by a suitable transormation to an uncorrelated set of lumped coefficients. But since the correlation matrices here are predominatly diagonal, the analysis will emphasize the diagonal terms.

Table 7 lists observation residuals and formal estimates of observation error (e), commission error (σ) and truncation error ΔT for the set of Vanguard lumped coefficients. The estimate of the commission error (for each lumped term) is calculated from the variance-covariance matrix (V) of PGS-162 as:

$$\sigma = [Q^T V Q]^{1/2}, \tag{6a}$$

where Q is the vector of influence coefficients for a particular lumped coefficient (Table 4). An (unrealistic) estimate of omission (truncation) error (derived from Kaula's rule) is

$$\delta T = [\Sigma Q^2 \times 10^{-10}/\ell^4]^{1/2},$$

over all appropriate terms beyond $\ell = 19$ for the particular lumped coefficient. This assumes there is no information on the lumped coefficients in the model.

To what extent are the actual residuals compatible with the formal error estimates? If independent truncation error were allowed, it alone could easily account for most of the residuals. The most sanguine view of PGS 162 is achieved if we ignore truncation error altogether, allow no bias in the formal observation error and ask to what extent the formal commission error is compatible with these residuals. Since O and C are independent random variables (note their different error correlations in Table 6), the variance of O-C is $e^2 + \sigma^2$. Evaluating a standard normal-type statistic $(Z = (O - C)/(e^2 + \sigma^2)^{1/2})$ would seem to be best in answering this question. This statistic is tabulated in Table 7 for each observation as well as for their sum which should have a variance of 12. Both the individual and sum Z scores appear quite acceptable. For example, computations might be rejected (as incompatible with the residuals) if the $|Z|$ scores were > 2, which would be expected to occur only 4% of the time. (On this basis, only the computed value for observation number 9 would be questionable). If the commission error is actually $\kappa\sigma$ for a constant κ over the Vanguard observations, a lower limit for κ could be set by the Z score test. But no upper limit is discriminated. For example, the assumption that the residual error is entirely in the observations ($\kappa = 0$) leads to a cumulative Z score of -5.9 (a very unlikely occurence). But, as seen, the Z test is not specific for the variance. In fact it is generally used only as a test of the 'mean'. Much more discriminating for σ is the χ^2 test.

If O-C is assumed to be random normally distributed with zero mean and variance $(\sigma')^2$, then $[(O-C)/\sigma']^2$, or Z^2, is χ_1^2 distributed with one degree of freedom. Further, if the residuals are all independent variables, $\sum_n [(O-C)/\sigma']^2$ will also be χ_n^2 having n as its expected value. (Even if the residuals ~~are not~~ independent the expected value of the sum is n.) Figure 7 shows the variation of χ_{12}^2 for the Vanguard 'observations' under a range of κ values where:

$$\sigma' = [e^2 + (\kappa\sigma)^2]^{1/2} .$$

There is a probability of 1/2 that this sum statistic is a sample of a population with the correct variance as long as $1.02 \leq \kappa \leq 1.40$. That is, 3/4 of the χ_{12}^2 population falls above 8.44 ($\kappa^2 = 1.02^2$), while 1/4 falls above 14.85 ($\kappa^2 = 1.40^2$). The expected value of κ^2 from the expected value of χ_{12}^2 (i. e. 12) is 1.18^2. A balanced estimate of κ with a probable variation is thus

$$\hat{\kappa} = 1.2 \pm 0.2,$$

much sharper than the estimate derivable from the Z scores.

Using $\hat{\kappa} = 1.2$, I list in Table 7 the (presumed) χ_1^2, scores for each Vanguard observation. If they were true χ^2 scores then α is the probability that the sample would have a score greater than or equal to the actual value (note that $E\chi_1^2 = 1.00$). All these probabilities are reasonable, even observation #9 is acceptable. Analogous to a $|Z|$ score rejection of > 2, it would only be rejected if $\alpha < .023$ (or $\alpha > .977$).

Considering the assumptions of statistical normality and independence, the PGS 162 solution calibrates very well with this data. It should be pointed out, however, that the formal errors of PGS 162 (reported here as σ) have been scaled up by $(0.1)^{-1/2} = 3.16$, an initial estimate based on the calibration (with surface gravity measurements) of the (similar) Gem 5 model (Lerch et. al., 1974, p. 31). Thus, the Vanguard calibration here (in terms of the original formal errors of PGS 162) is actually $\kappa' = 3.16 \times (1.2 \pm 0.2) = 3.8 \pm 0.6$ for the 11th order terms. This result is quite satisfactory. The average calibration factor for all the terms of Gem 5 was 3.4 (but see additional discussion later).

Correlated Error Matrix

A formal answer can be given to the expectation of the correlated observation residuals [Equation (6)] in terms of the error sources. Where the error matrix is highly correlated it can be diagonalized with respect to truly independent lumped coefficients. Statistics for these variables would be more reliable and would include all the error information. As a full error matrix ($n \times n$, n = number of residuals):

$$
\begin{aligned}
E(O-C)^2 &= E[(O-C)(O-C)^T] \\
&= E[(\Delta O + \Delta C + \Delta T)(\Delta O + \Delta C + \Delta T)^T] \\
&= E(\Delta O \Delta O^T) + E(\Delta O \Delta C^T) + E(\Delta O \Delta T^T) \\
&\quad + E(\Delta C \Delta O^T) + E(\Delta C \Delta C^T) + E(\Delta C \Delta T^T) + E(\Delta T \Delta O^T) + E(\Delta T \Delta C^T) + E(\Delta T \Delta T^T)
\end{aligned}
\tag{7}
$$

In this notation superscript T denotes transpose. Actually the matrix is symmetric since $(O-C)_i\ (O-C)_j = (O-C)_j\ (O-C)_i$ for residuals i and j. Furthermore $E(\Delta O \Delta O^T) = e^2_{ij}$, $E(\Delta C \Delta C^T) = \sigma^2_{ij}$ and $E(\Delta T \Delta T^T) = \delta^2 T_{ij}$, the correlated error matrices of the observations, computed values and omitted terms (if any are considered).

Even if a simple rule such as Kaula's is used, $\delta^2 T_{ij}$ is still not diagonal although the omitted gravitational terms are considered to be independent with zero expectation. The diagonal terms are computed (for the ith observation) as:

$$\delta^2 T_{ii} = E(\Delta T_i^2)$$

$$= E\left(\sum_{\ell} Q \times H_{\ell}\right)_i^2 ,$$

for the appropriate harmonics H and influence factors Q. But $E(H_p H_q) = 0$, for $p \neq q$ since (again) the omitted harmonics are assumed to be independent with zero expectation. Thus,

$$\delta^2 T_{ii} = E(\Sigma Q^2 H^2)_i \tag{7a}$$

$$= [\Sigma Q^2 E(H)^2]_i .$$

Similarly, off diagonal exist where the harmonics involved are the same since

$$\delta^2 T_{ij} = E(\Sigma QH)_i \; (\Sigma QH)_j \tag{7b}$$

$$= \Sigma E Q_i Q_j H^2 = \Sigma Q_i Q_j E(H^2).$$

Using Kaula's rule, $E(H)^2 = (10^{-5}/\ell^2)^2$. The e_{ij}^2 matrix is merely the observation correlation matrix pre and post multiplied by the vector of standard deviations for the lumped coefficients (Table 6):

$$e_{ij}^2 = SD_i^T COR_{ij} SD_j$$

But, since SD has only one member for each observed lumped coefficient;

$$e_{ij}^2 = SD_i COR_{ij} SD_j$$

The error matrix for the computed values has already been given (for the diagonal terms) in Equation (6a). For all the terms:

$$\sigma^2_{ij} = Q_i^T V Q_j,$$

where i and j refer, in general, to different lumped terms.

The (unique) cross expectations [e. g., $E(\Delta O \Delta C^T)$, $E(\Delta O \Delta T^T)$ and $E(\Delta C \Delta T^T)$] are zero, for different reasons. $E(\Delta O \Delta C^T) = 0$ because the observations of the lumped coefficients from deep resonance (O) and from shallow resonance (C) are essentially independent. Most of the deep resonances were observed with completely different tracking data (NAVSPASUR). Even the (11, -3) and (11, -2) resonances using much the same basic tracking data, use fundamentally independent methods. The deep resonant observations were made from the dynamic evolution (over months) of mean elements (principally the orbit inclination). The shallow resonant information in PGS 162 is principally shorter period along track fluctuations within each 7 day arc. In fact the critical observations of these resonances in the Goddard models may not have been from the "deep resonant" Vanguard 3 and Vanguard 2 rocket orbits at all but from the truly shallow resonant Vanguard 2 orbit.

$E(\Delta O \Delta T^T)$ and $E(\Delta C \Delta T^T) = 0$ since the truncated harmonics are independent of the calculated (or observed) ones and $E(\Delta O) = E(\Delta C) = E(\Delta T) = 0$. (Of course, if the model "observes" the data also, then $E(\Delta C \Delta T^T) \neq 0$.) The final results for the full error matrix (assuming independent truncation error) are:

$$E(O - C)^2_{ii} = e^2_{ii} + \sigma^2_{ii} + \delta^2 T_{ii},$$

for the diagonal terms (i = 1, 2, 3, . . . 12), and (8)

$$E(O-C)_i\ (O-C)_j = e^2_{ij} + \sigma^2_{ij} + \delta^2 T_{ij}$$

for the off diagonal terms ($i \neq j$).

It is noted that e^2_{ij} and σ^2_{ij} are necessarily positive only for $i = j$. The full error correlation matrix (with $\Delta T = 0$ for 11th order terms) for $\kappa = 1$ is listed in Table 6a. The $E(O-C)_{ij}$ are given on the diagonal and the $E(O-C)_i\ (O-C)_j$ are $cor_{ij}\ [E\ (o-c)^2_i\ E\ (o-c)^2_i]^{1/2}$. Considering only the errors of observation, commission and truncation (for 22nd order terms only), Table 6a shows that the residuals are expected to be only mildly correlated. There is justification, then, in using the sum statistic as χ^2 to calibrate (with bounds) the PGS solution.

As mentioned before, (and providing the expected truncation error is properly estimated), it is possible to diagonalize the total error matrix and work with truly independent 'residuals'. It should be noted in passing that there will be a different error matrix (and different independent residuals) for each factor κ since the PGS error matrix is scaled by κ. But none of this refinement appears justified. The error matrix is only moderately correlated and the truncation error is poorly assessed, though the best indications are that the total effect is small.

In all of this analysis, the 22nd order results have been ignored. But no other solution is available for these terms. As far as the calibration of PGS 162 is concerned these terms only have the indirect effect of redistributing the observation errors slightly. However, the residuals involving the 22nd order coefficients do provide a direct calibration of Kaula's rule since they are uncoupled from the PGS errors.

For example, using Kaula's rule and only the diagonal 22nd order terms in Table 6a, the sum χ^2 statistic $[\Sigma\,(O-C)^2_i/E(O-C)^2_i]$ is:

$$\chi_6^2 = 13.3.$$

A value greater than this would be expected to occur only 3.5% of the time if Kaula's rule were true. However a normal statistic rejected at the $2\sigma_+$ level can occur there 2.3% of the time.

RESULTS AND ADDITIONAL DISCUSSION

14 years of mean elements for Vanguard 3 and 7 years for Vanguard 2 rocket have been analysed for 11th and 22nd order geopotential terms. Significant resonances in the orbit's inclination have been used for this purpose. Fluctuations have been observed of up to 0.035° in Vanguard 3's inclination and 0.017° in Vanguard 2 rocket's. Twelve lumped coefficients for 11th order terms have been derived from this record with precisions ranging from 1 to 17×10^{-9}. This corresponds to a precision of from 0.6 to 11 cm in geoid height. Ten of the coefficients are "known" to a level of better than 2 cm in geoid height. Estimated accuracies for these terms in a comparison gravity field (PGS 162) using conventional tracking and parameter determination systems ranges from 7.6 to 18.4×10^{-9} (5 to 12 cm). This field uses the same orbits as analysed here but suffers from the difficulty of extracting the resonant information from only 7 day orbital arcs. The Vanguard resonances (in the comparison field) in the early 1960's had periods of from 2 weeks to more than a year.

A calibration of the PGS 162 field with this resonant data shows good overall agreement. The gross correlation coefficient (between observed and computed lumped terms) is 0.88. The formal errors in the 11th order terms of this comparison field are compatible with the resonance observations if they are scaled by 3.8. This factor is close to the overall calibration of the similar

Gem 5 satellite geopotential using surface gravimetry data. It should be said however, that the 11th order resonances here have been observed (albeit not as well as they might) in PGS 162, which contains no surface data. It is also clear that the calibration factor of 3.8 is undoubtedly too high because:

1. No truncation error has been allowed in the initial comparison. Actually the PGS field has probably suffered some loss of the resonant information in the inclination by its truncation to (19, 11). The computed errors for PGS 162 from its diagonal terms are only about twice the errors from the full matrix (Table 7). A similar calculation for the 13th order inclination resonance of the D1D satellite (truncated in PGS 162 at 29, 13) shows a ratio of close to 6:1. This indication of a rather weak tie to the Vanguard inclination resonance at (19, 11) is confirmed by comparison between two 11th order PGS models of different truncation. Taking into account a more realistic estimate of the truncation error reduces the PGS 162 calibration factor to 3.3 ± 0.5. (This lower factor is used for the PGS accuracy estimates above).

2. No allowance has been made for the effect of unresolved systematic errors in the "observations". That such biases are present is clear from Figures 1, 2 and 5 discussed earlier. I believe these effects are minor because they are relatively small in the deepest parts of the resonances. (Where the data contributes most to the determination). A recent suggestion by S. M. Klosko is that the "wing biases" may be due (in part) to a lack of adequate ionospheric refraction correction in the NAVSPASUR direction cosines.

22nd order (lumped) terms have also been derived from the NAVSPASUR data. The derivation is weak but statistically significant. The formal errors are greater than those for 11th order (ranging from 5 to 13×10^{-9}). However, the results are probably more affected by the "wing biases" than the 11th order terms because their deep resonant passage is half as long. The 22nd order results show sensitivity to geopotential terms as high as 41st degree and the lumped terms are somewhat greater than predicted by Kaula's rule. This is counter to most of the resonances seen for orders 11 through 15 (e. g. Figure 6) for 11th order terms).

It is recalled that in order to use satellite altimetry data to observe large scale ocean dynamics, the geoid will have to be known to the 10 cm level (Kaula, et. al., 1969). The observations of 11th order geopotential terms from these Vanguard resonances meet this criteria. No current satellite geopotential is adequate for this purpose, not even their resonant terms. However it is encouraging that a combination solution (such as PGS 63) with surface gravity actually improves (significantly) the satellite result for 11th order terms. Certainly the combination of the deep resonant observations with the conventional satellite model will result in adequate 11th order terms.

ACKNOWLEDGMENT

I am indebted to Robert Cote and Richard Smith for providing (and explaining) the NAVSPASUR mean elements which constitute the "new" observations in this report. Jean Roy executed the many computer runs necessary in the study. She should be especially proud of her contribution to the graphics in Figures 1 and 2. Herbert Huston, besides maintaining the Road "system", made significant program changes to speed the graphics computation. Mr. Huston also calculated the error data for PGS 162. This work has also benefitted from stimulating discussions with D. G. King Hele, F. J. Lerch and S. M. Klosko.

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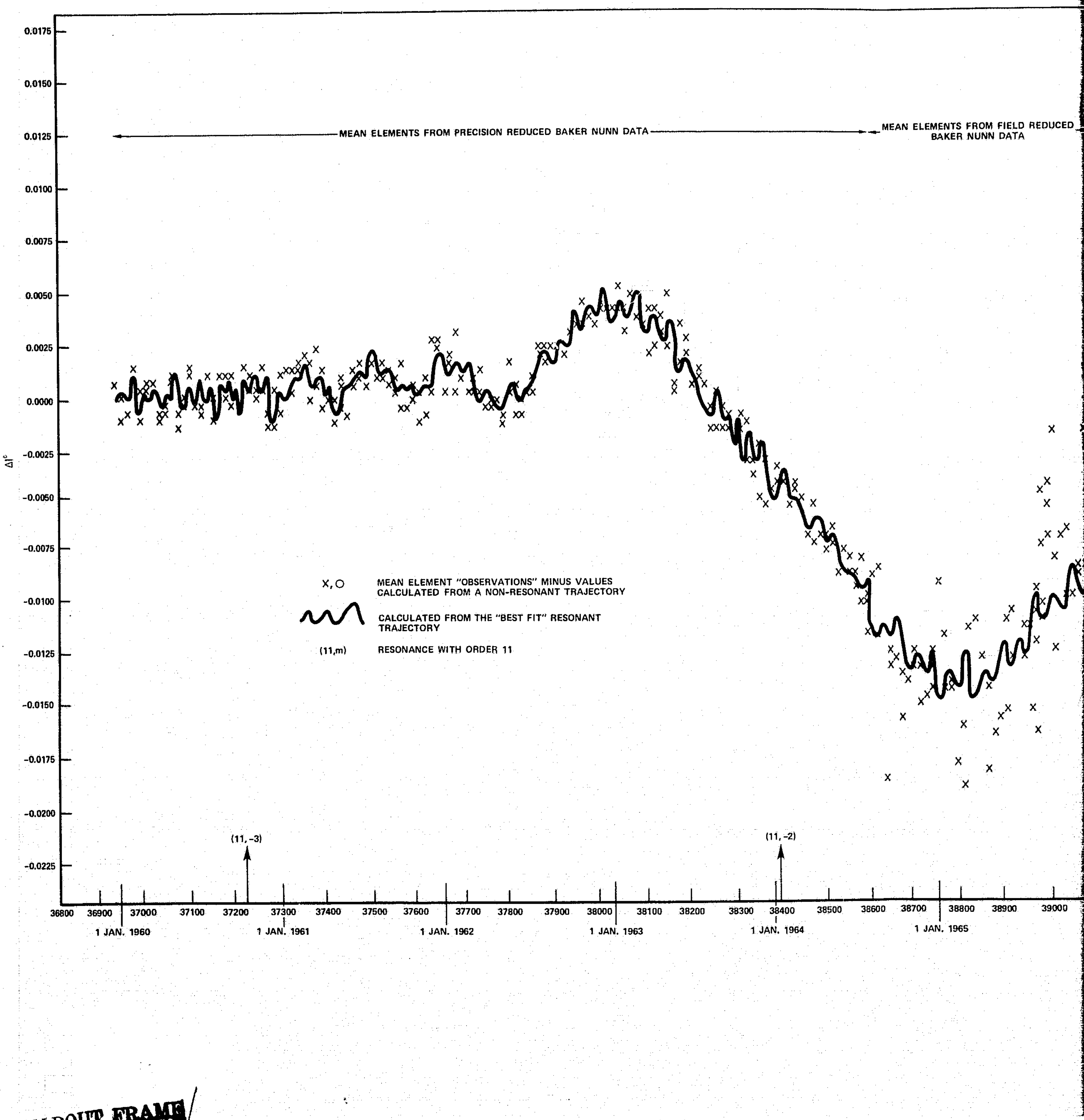

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FIGURE 1
RESONANT VARIATION OF THE ORBIT
INCLINATION OF VANGUARD 3 (1959–7A)
(AVERAGE INCLINATION = 33.35°)

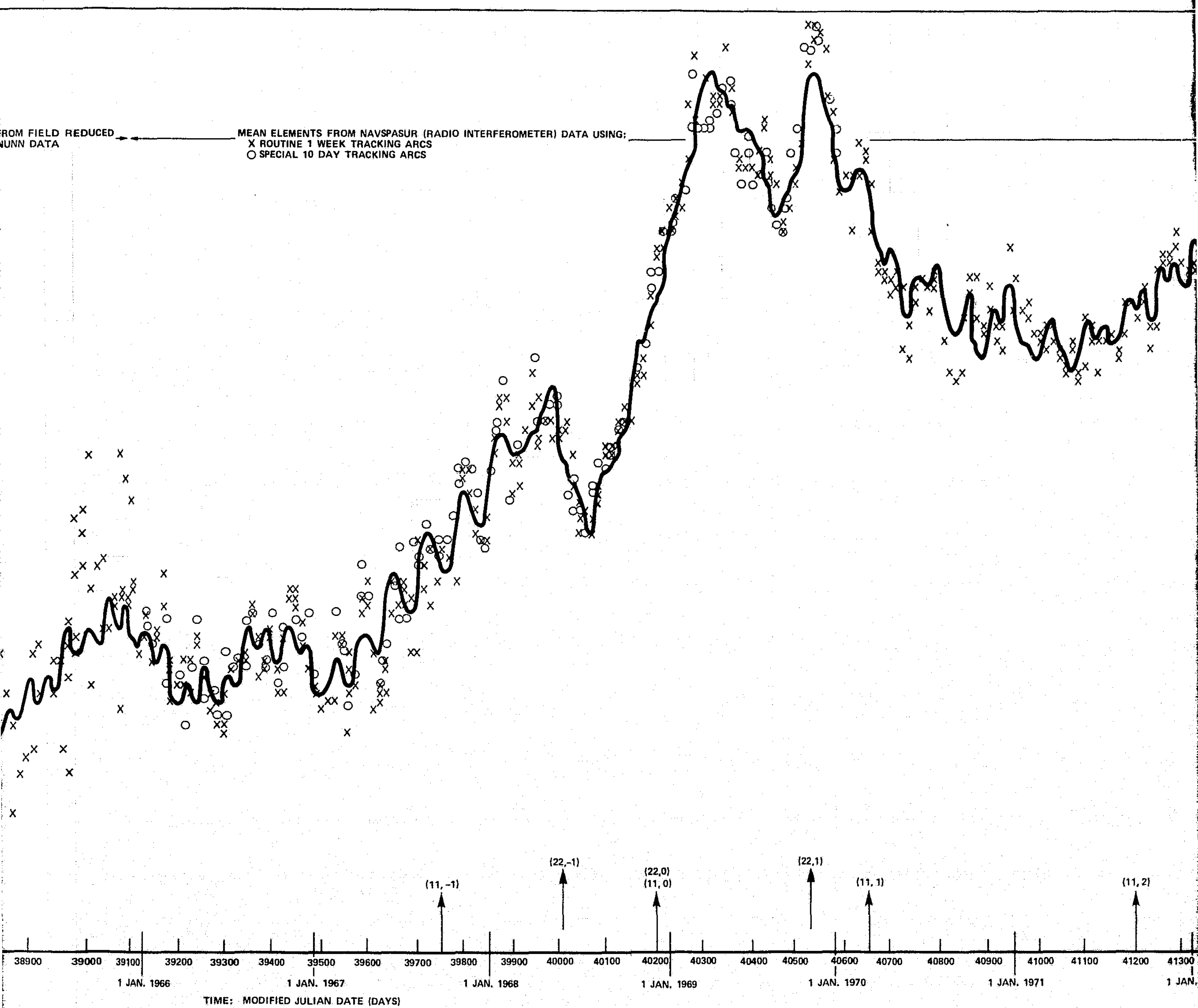

Figure 1. Resonant Variation of the Orbit Incli
(Average Inclination = 3

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ORBIT
1959—7A)

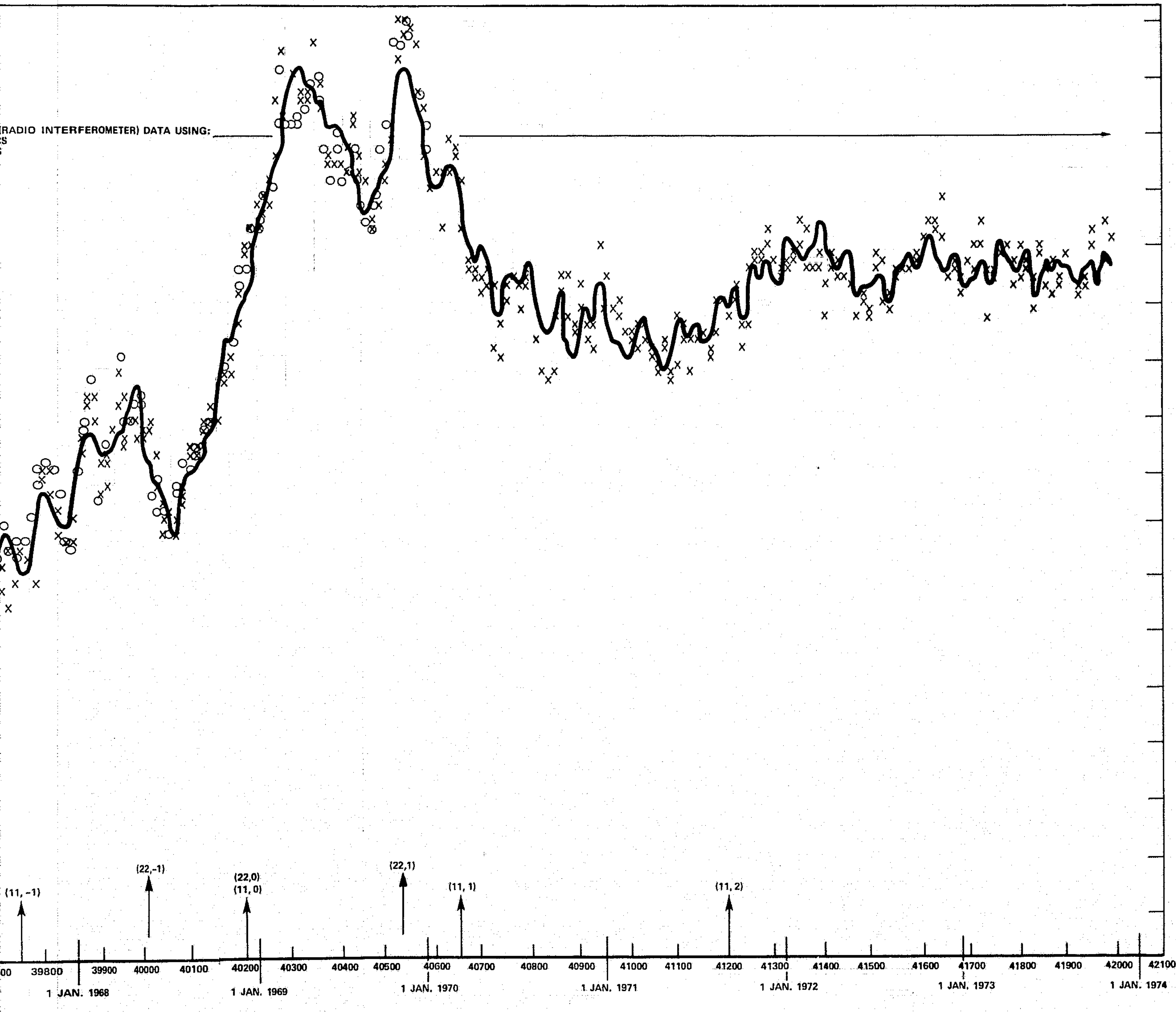

Figure 1. Resonant Variation of the Orbit Inclination of Vanguard 3 (1959-7A) (Average Inclination = 33.35°)

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RESONANT V
INCLINATION OF V
(AVERAG

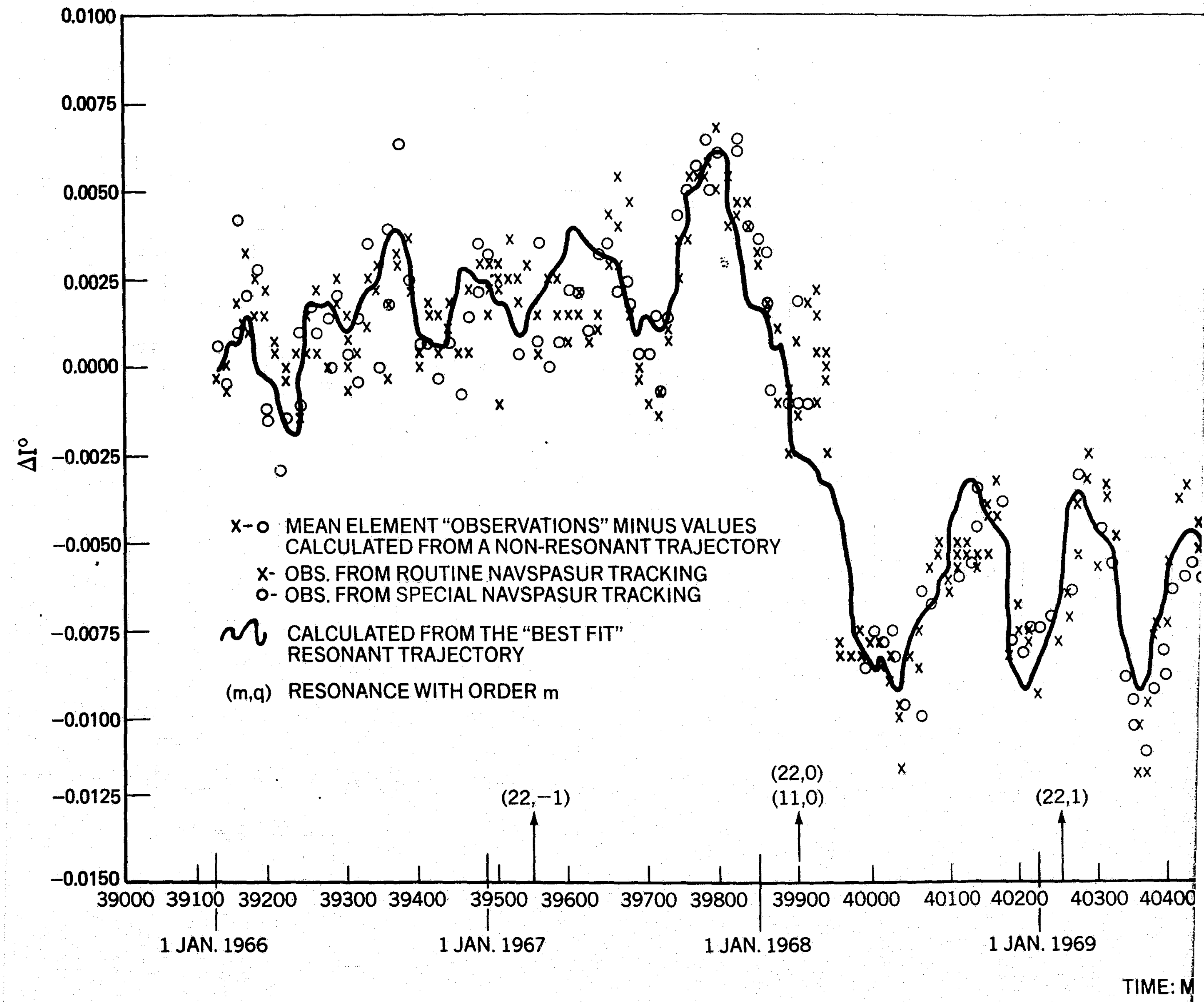

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FIGURE 2

SONANT VARIATION OF THE ORBIT
'ION OF VANGUARD 2 ROCKET (1959-2B)
(AVERAGE INCLINATION=32.91°)

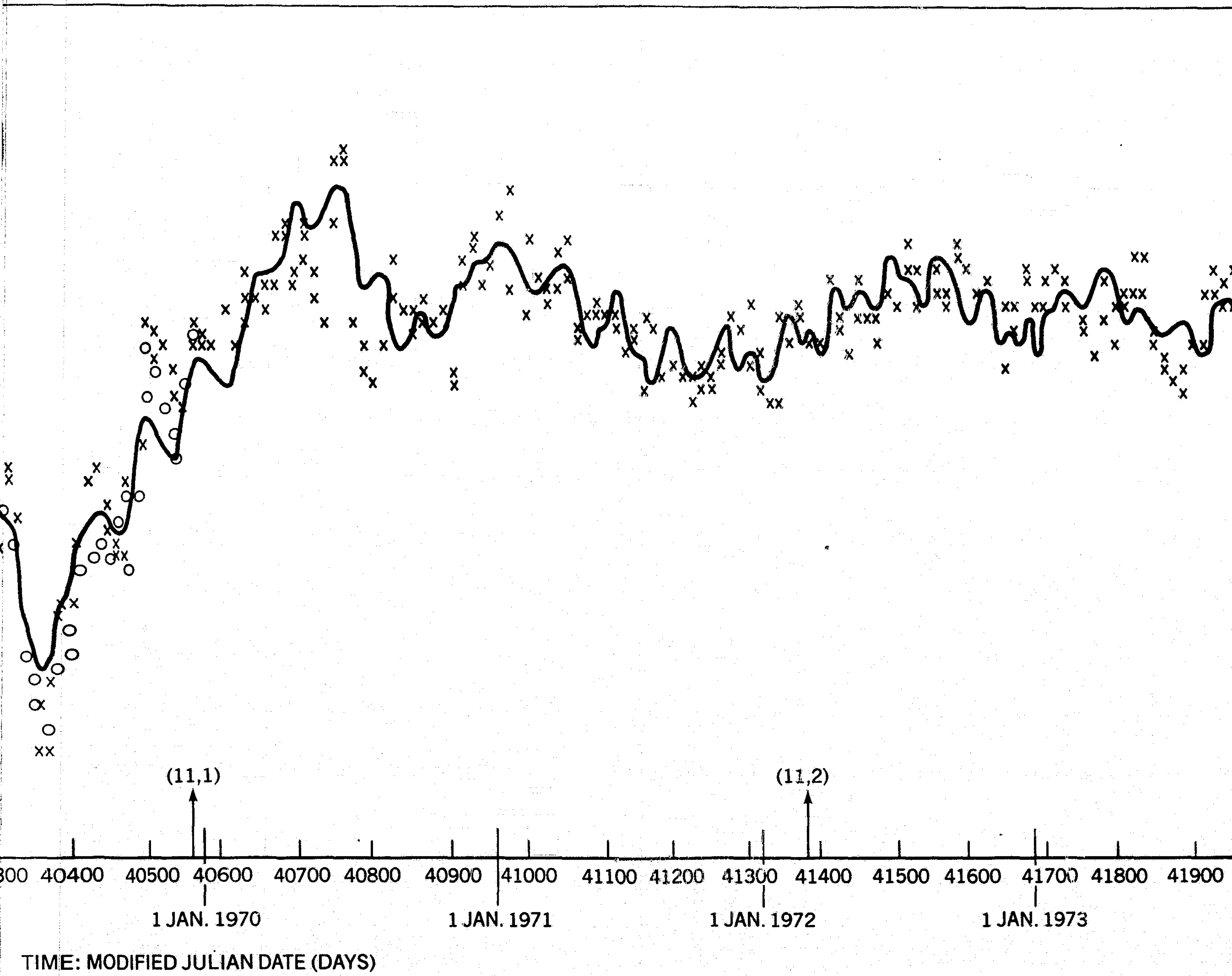

Figure 2. Resonant Variation of the Orbit Inclination of Vanguard 2 Rocket (1959-2
(Average Inclination = 32.91°)

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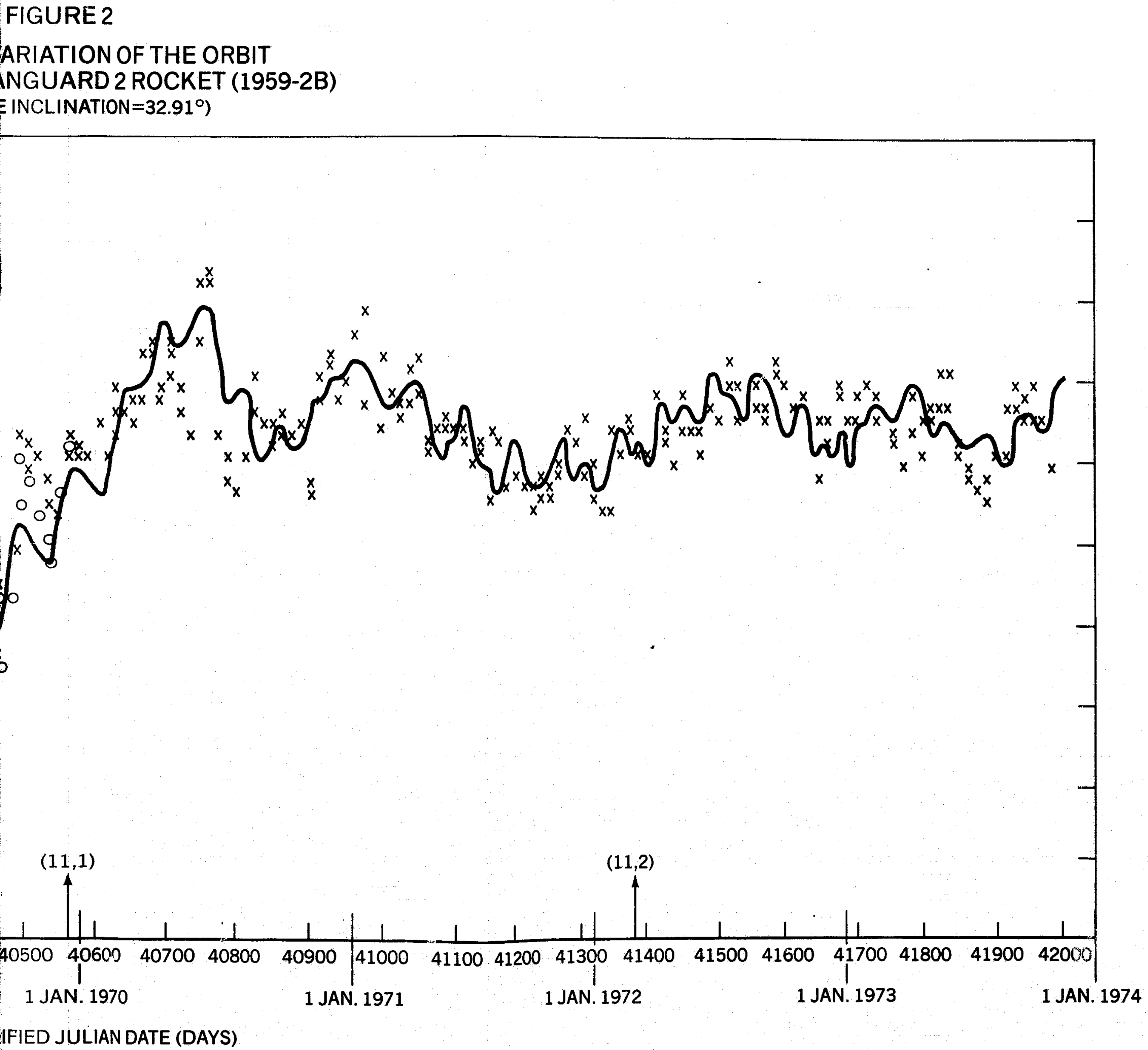

Figure 2. Resonant Variation of the Orbit Inclination of Vanguard 2 Rocket (1959-2B)
(Average Inclination = 32.91°)

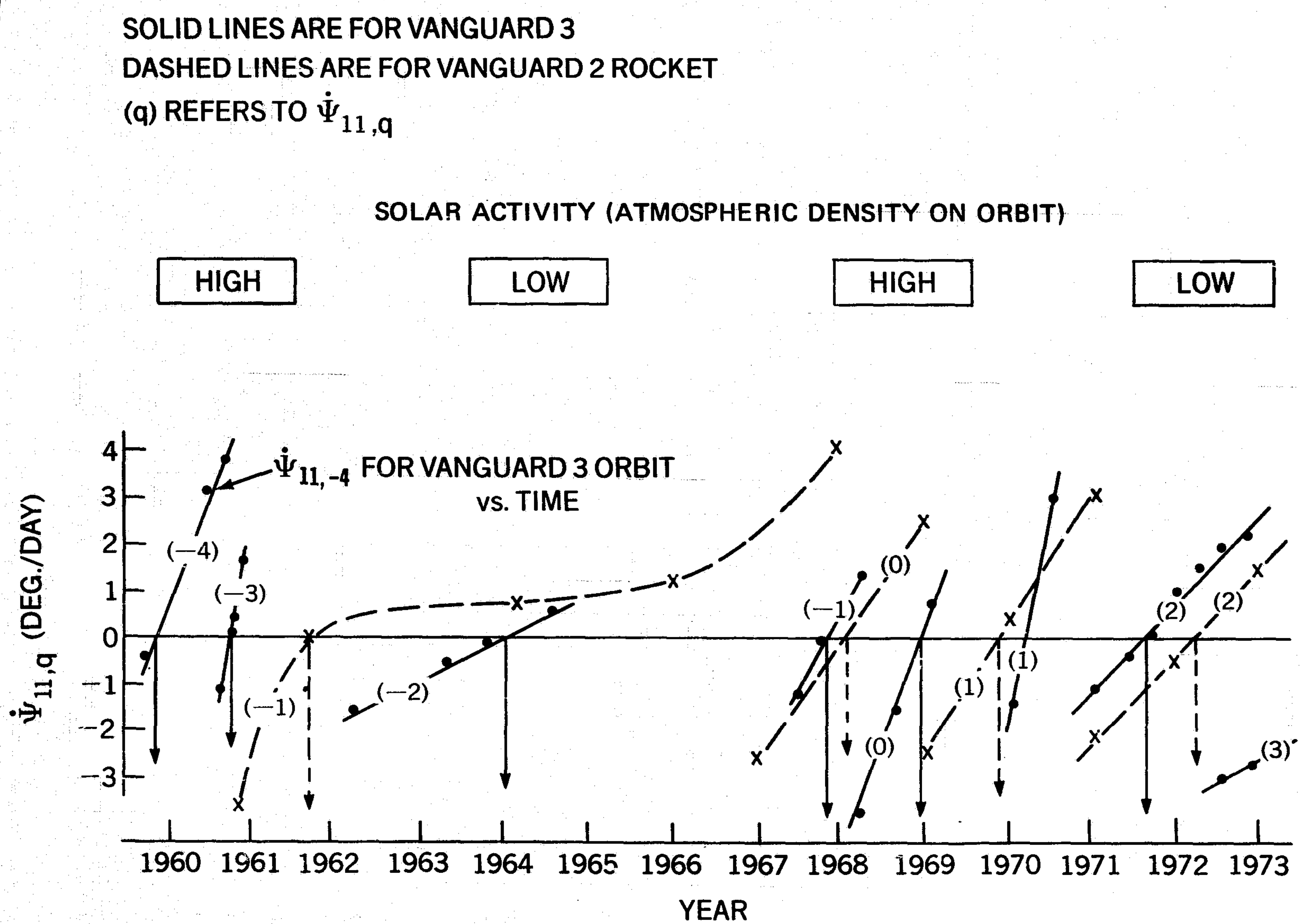

Figure 3. 11th Order Resonance Times for Vanguard Orbits

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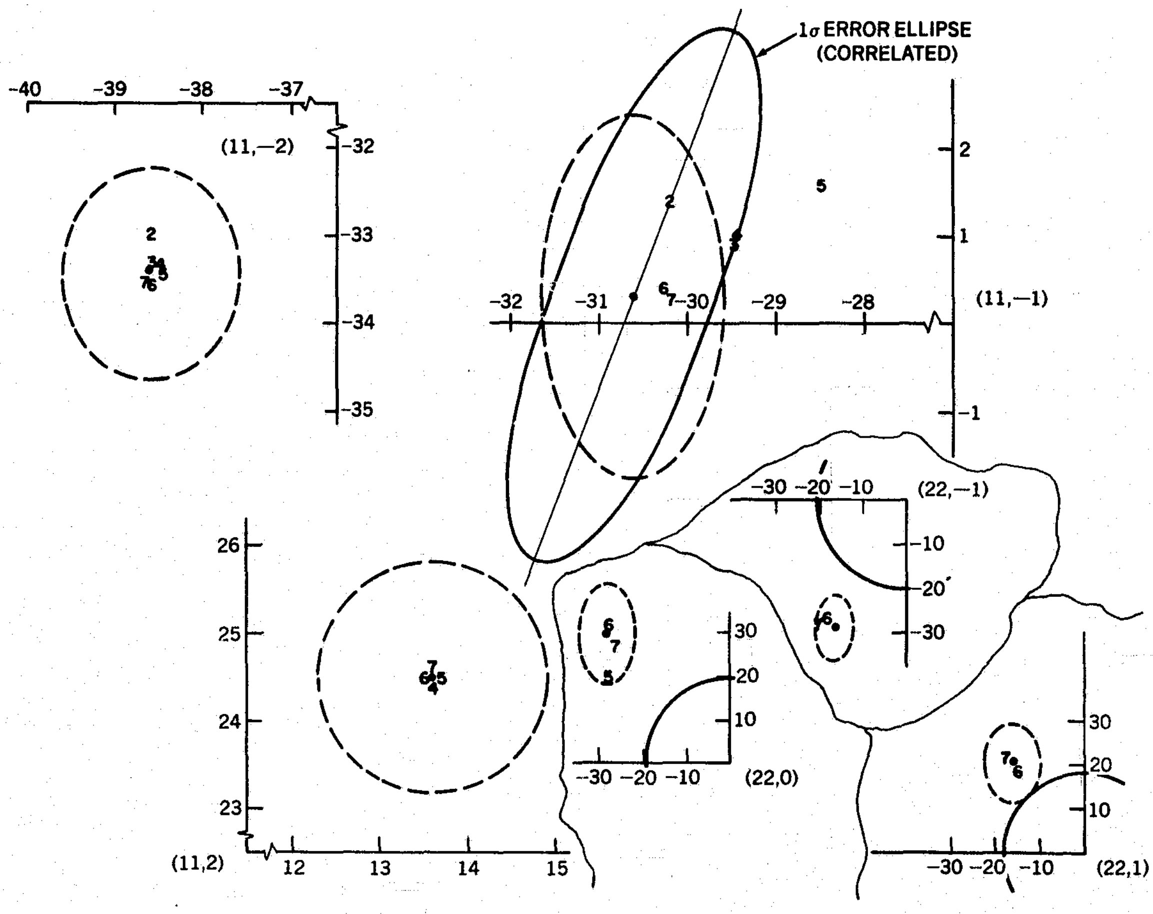

BEST VANGUARD SOLUTION (RUN 8) WITH 1σ ERRORS (UNCORRELATED)

2-7 OTHER SOLUTIONS (SEE TABLE 3)

ESTIMATED AMPLITUDE FROM KAULA'S RULE

Figure 4a. Vanguard Multi-Arc Solutions (Lumped Harmonics): Units: 10^{-9}

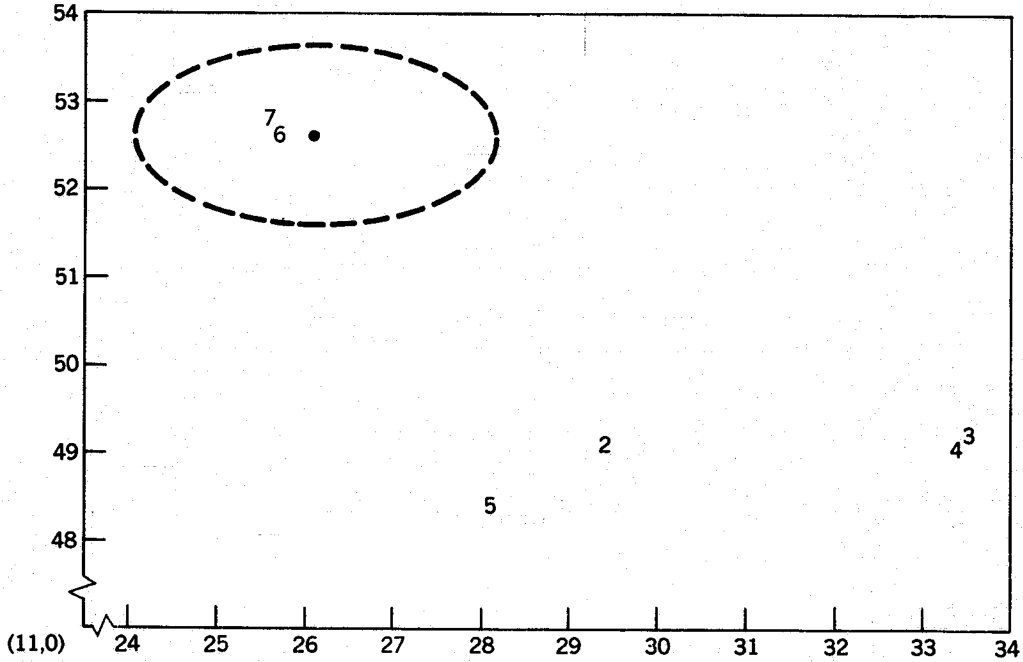

Figure 4b. Vanguard Multi-Arc Solutions (Lumped Harmonics): Units: 10^{-9}

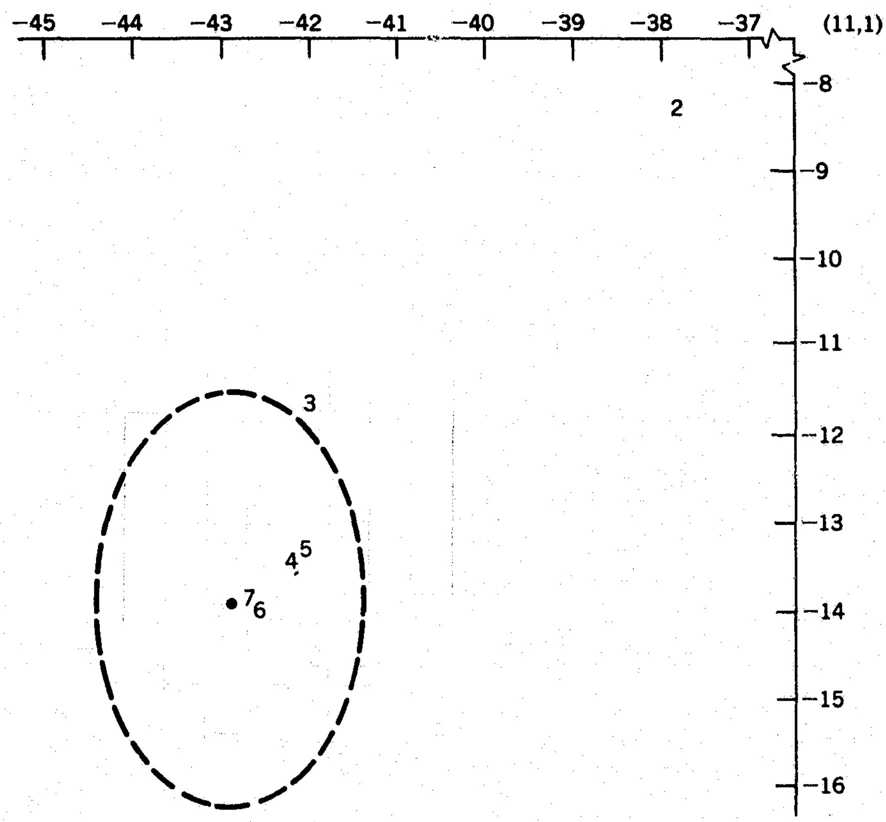

Figure 4c. Vanguard Multi-Arc Solutions (Lumped Harmonics): Units: 10^{-9}

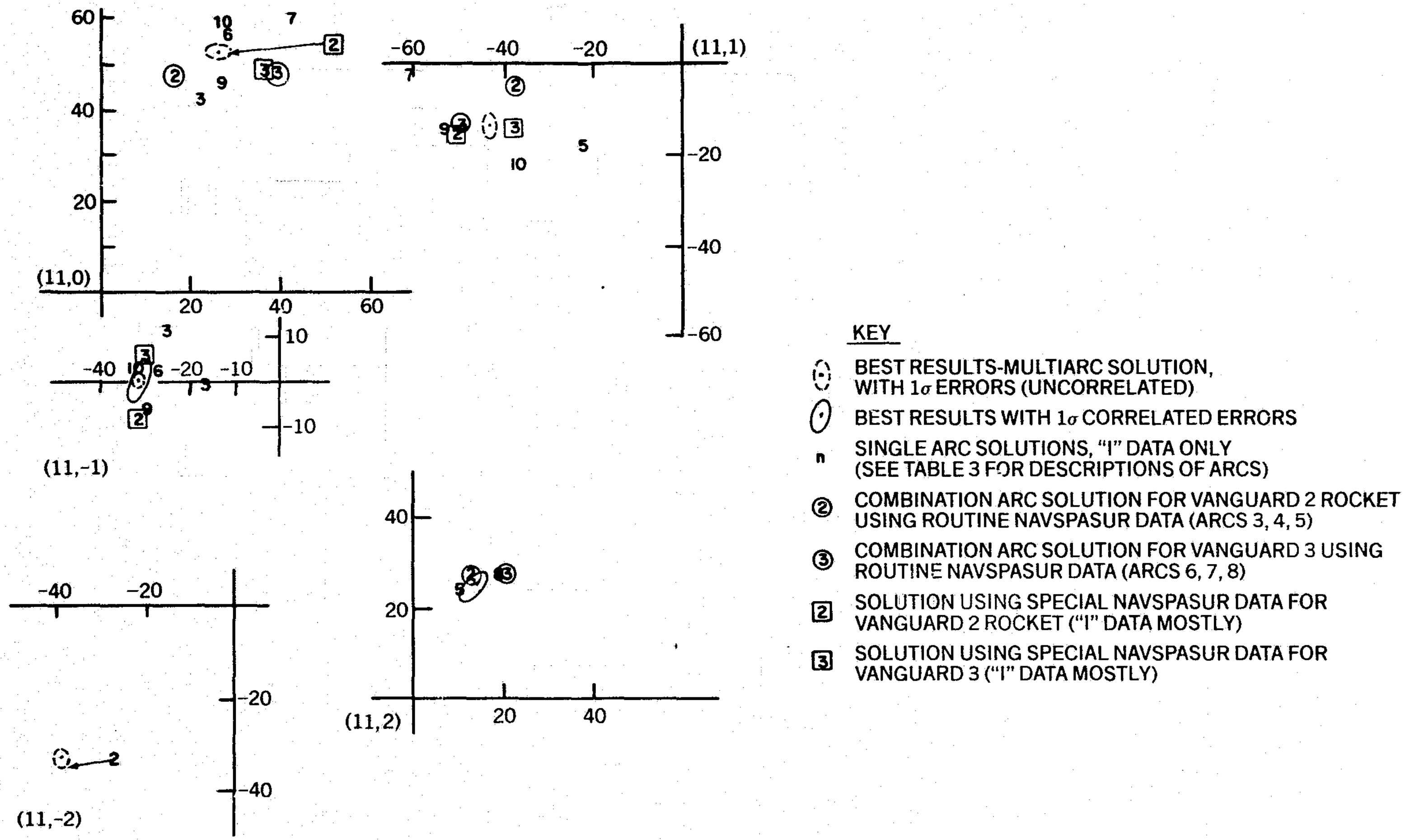

Figure 5. Vanguard Single and Combination Arc Resonant Solutions
Units: 10^{-9}

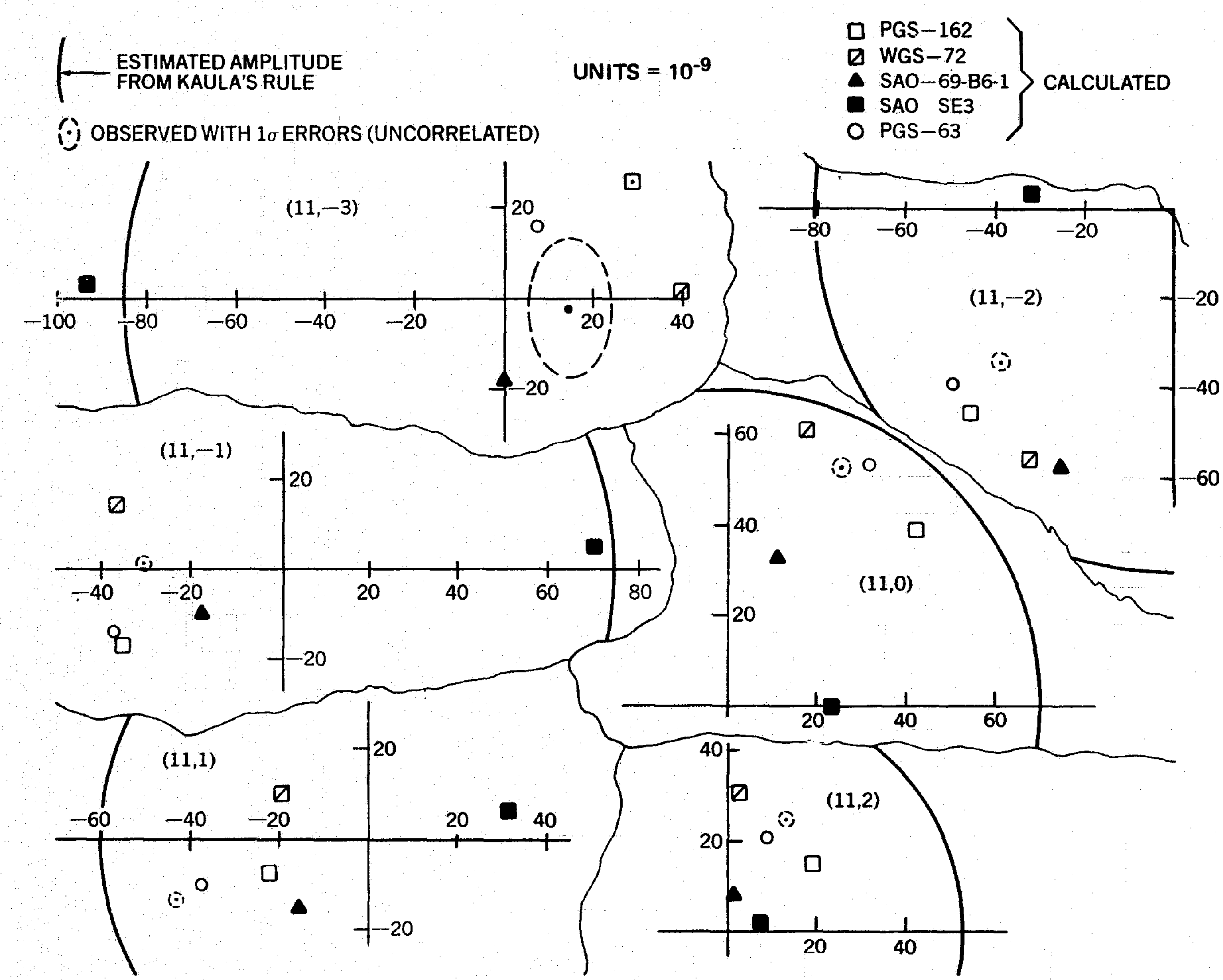

Figure 6. Lumped Harmonics for Vanguard Resonances: Units: 10^{-9}

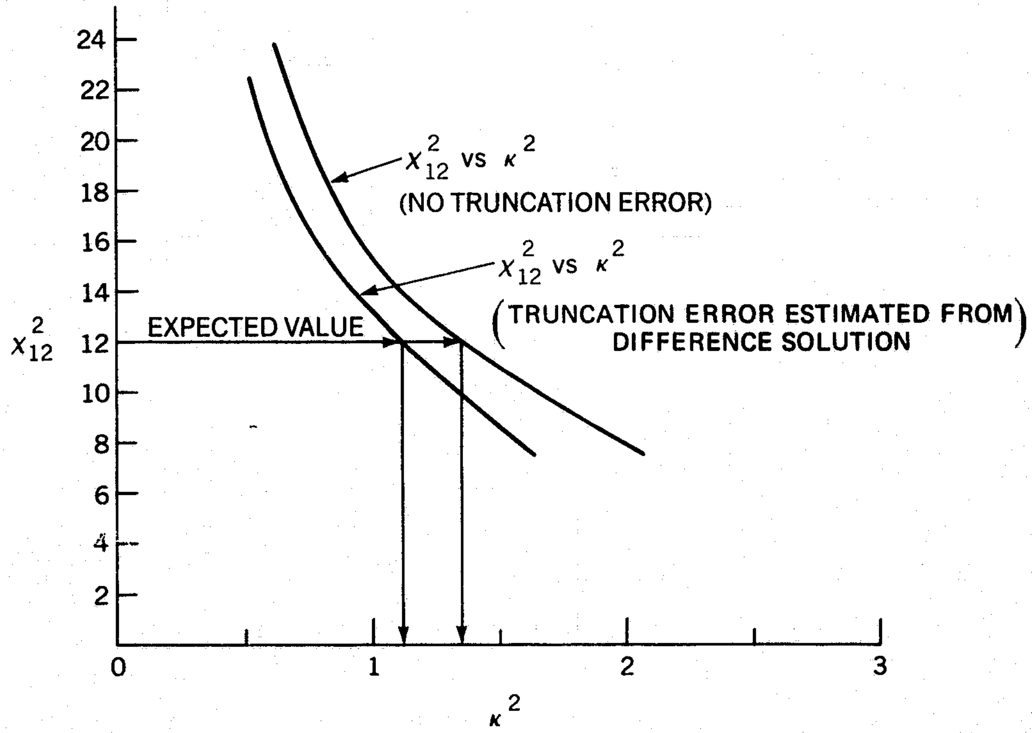

Figure 7. Variation of Error Statistic with Calibration Factor for PGS 162

Table 1a
Mean Element Observations – ARC 1
(Vanguard 3 - from Precise Baker-Nunn Tracking)
(X-Data Edited Out)

TIME (MJD)	A (e.r.)	E	INCL (DEG'S.)	OMEGA (DEG'S.)	NODE (DEG'S.)	MEAN ANOM. (DEG'S.)
36942.49861000	1.33428560	.1896925	33.3572	325.5251	222.4867	22.6924
36948.00694000	1.33423750	.1898303	33.3518	352.4002	204.4549	3.0120
36954.96111000	1.33421930	.1901174	33.3486	26.3033	181.6850	342.7363
36961.92546000	1.33421640	.1903522	33.3451	60.1296X	158.9172 X	317.5753X
36968.95555000	1.33421130	.1904340	33.3450	94.3596	135.8545	287.1632
36976.08611000	1.33418200	.1902542	33.3498	129.0378	112.5036	251.6787
36986.00972000	1.33416820	.1898679	33.3552	177.3680	80.0074	183.0447
36993.04722000	1.33415360	.1895849	33.3589	211.6892	56.9627	137.7905
37000.08472000	1.33414220	.1894373	33.3635	246.0544	33.9237	92.9854
37007.03472000	1.33413330	.1893503	33.3651	280.0019	11.1703	60.0573
37014.25694000	1.33407740	.1894062	33.3629	315.2651	347.5306	32.1267
37021.02777000	1.33411340	.1895833	33.3590	348.3270	325.3633	6.5117
37028.07083000	1.33402270	.1897928	33.3518	22.6585	302.3001	346.3325
37035.02222000	1.33400220	.1900244	33.3463	56.5193	279.5309	321.8691
37042.06250000	1.33400370	.1900572	33.3447	90.7467	256.4664	292.4373
37049.46111000	1.33397010	.1902097 X	33.3465	126.8465 X	232.2334	251.5072
37056.04583000	1.33394030	.1896120	33.3513	158.8229	210.6602	208.8857
37063.08055000	1.33391760	.1893341	33.3544	193.1545	187.6197	159.8556
37070.02638000	1.33389630	.1891198	33.3553	227.0791	164.8676	117.3401
37077.02777000	1.33386330	.1890520	33.3559	261.2949	141.9343	296.8303
37084.06527000	1.33386570	.1890385	33.3575	295.6828	118.8795	260.7098
37091.05138000	1.33385450	.1891636	33.3574	329.8109	95.9962	20.3893
37098.00277000	1.33382970	.1893653	33.3564	3.7537	73.2277	2.4802
37105.04166000	1.33381370	.1896415	33.3521	38.0633	50.1677	334.1815
37112.07917000	1.33374940	.1897951	33.3481	72.3529	27.1036	306.5678X
37122.09440000	1.33372040	.1897072	33.3488	121.0781	354.2846	256.9149
37126.06390000	1.33370450	.1895825	33.3512	140.4169	341.2761	237.7081
37133.00690000	1.33367560	.1892819	33.3551	174.2694	318.5253	190.9633
37140.03890000	1.33364190	.1890621	33.3598	208.6106	295.4844	139.4864
37147.07220000	1.33361650	.1889198	33.3598	243.0014	272.4353	94.3897
37154.01610000	1.33360180	.1889069	33.3575	276.9559	249.6710	61.1508
37161.05550000	1.33356480	.1889448	33.3564	311.3727	226.6004	33.9591
37168.18330000	1.33353410	.1891328	33.3549	346.2178	203.2345	8.1362
37175.04030000	1.33348980	.1893897	33.3501	19.7090	180.7544	344.2052
37182.03610000	1.33346970	.1896634	33.3473	54.0118X	157.6771X	321.1221X
37189.02360000	1.33341850	.1897954	33.3444	87.8485	134.8957	293.7518
37196.05690000	1.33332090	.1896017	33.3472	122.0792	111.8178	257.0499
37203.08470000	1.33326490	.1894293	33.3503	156.3833	88.7511	211.3828X
37210.02780000	1.33321430	.1891197	33.3567	190.2781	65.9809	167.4411
37217.05690000	1.33318130	.1889171	33.3633	224.6660	42.9212	119.3550
37224.08750000	1.33313070	.1888115	33.3655	259.0770	19.8583	78.1428
37231.03055000	1.33309480	.1888479	33.3648	293.0461	357.0784	49.2632
37238.06380000	1.33307340	.1889835	33.3613	327.4834	333.9994	21.3237
37245.00830000	1.33304310	.1891999	33.3566	1.4330	311.2077	359.7521
37252.22220000	1.33302590	.1894912	33.3509	36.6683	287.5276	334.0110
37259.07500000	1.33298780	.1896301	33.3484	70.0824	265.0272	309.1265
37266.01670000	1.33296970	.1896421	33.3462	103.9210	242.2340	279.4560
37273.04580000	1.33295190	.1894256	33.3461	138.1975	219.1546	239.2689
37280.70280000	1.33292330	.1891343	33.3505	175.6004	194.0091	183.9351
37287.00970000	1.33289790	.1888749	33.3533	206.4478	173.3041	143.7487
37294.03750000	1.33289030	.1887354	33.3582	240.8568	150.2319	99.5438
37301.15690000	1.33287970	.1887002	33.3614	275.7333	126.8569	61.3972
37308.00833000	1.33287610	.1887775	33.3598	309.2742	104.3635	34.3349

Measurement Residuals (Observed Minus Computed) rms from Run #8 (Table 3)

A (E.R.)	E	INCL (DEG'S.)	OMEGA (DEG'S.)	NODE (DEG'S.)	MEAN ANOM. (DEG'S.)
0.3350D-04	0.2280D-04	0.7360D-03	0.1320D-01	0.7690D-02	0.9250D 00

Table 1b
Observations – ARC 2
(Vanguard 3 – From Precise Baker-Nunn Tracking)

TIME (MJD)	A (e.r.)	E	INCL (DEG'S.)	OMEGA (DEG'S.)	NODE (DEG'S.)	MEAN ANOM. (DEG'S.)
37315.40140000	1.33287330	.1889338	33.3590	345.4664	80.0897	8.6037
37322.07360000	1.33284930	.1891909	33.3539	18.0779	58.1833	347.4229
37329.19580000	1.33284840	.1894391	33.3509	52.8693	34.7932	321.8189
37336.04720000	1.33283000	.1895110	33.3496	86.2779	12.2916	296.0275
37343.07640000	1.33283130	.1894589	33.3514	120.5577	349.2040	259.7657
37350.01390000	1.33282210	.1891846	33.3549	154.4246	326.4215	217.9871
37357.03890000	1.33281880	.1889138	33.3576	188.7666	303.3556	165.4830
37363.07500000	1.33280260	.1887086	33.3580	218.3138	283.5362	127.6701
37370.01250000	1.33279230	.1886048	33.3604	252.2814	260.7574	86.2266
37377.31250000	1.33279500	.1885856	33.3609	288.0567	236.7840	51.2017
37384.07360000	1.33280320	.1886639	33.3578	321.1730	214.5837	26.3398
37391.01540000	1.33279760	.1888876	33.3548	355.1591	191.7913	2.0690
37398.13750000	1.33278390	.1891405	33.3478	29.9723	168.4014	338.4506
37405.07920000	1.33277590	.1893754	33.3436	63.8545	145.6000	314.6172
37412.01940000	1.33277130	.1894153	33.3431	97.7168	122.7996	285.4247
37419.04720000	1.33276740	.1893167	33.3452	132.0024	99.7116	245.4402
37426.07360000	1.33277070	.1890309	33.3525	166.3119	76.6347	199.9366
37432.01810000	1.33276780	.1888126	33.3588	195.3802	57.1124	157.6462
37439.94510000	1.33276460	.1888506X	33.3631	234.0716X	31.0903	108.8296X
37447.24440000	1.33275400	.1885528	33.3701X	269.9570	7.1108	69.6480
37452.92220000	1.33277210	.1885901	33.3620	297.7801	348.4760	43.5616
37459.77260000	1.33278200	.1888000X	33.3606	331.3237	325.9800	20.1626X
37466.35420000	1.33275330	.1890336	33.3568	3.5199	304.3706	356.1937
37473.29580000	1.33274840	.1892910	33.3508	37.4479	281.5719	333.1700
37480.05690000	1.33274500	.1894857	33.3471	70.4289	259.3617	309.8920
37487.08710000	1.33274570	.1894801	33.3450	104.7219	236.2660	276.1860X
37494.02360000	1.33274070	.1893021	33.3461	138.5758	213.4733	236.8072
37501.05000000	1.33273330	.1890460	33.3517	172.9180	190.3912	192.2477
37508.07500000	1.33273700	.1887792	33.3563	207.2867	167.3178	142.2167
37515.01110000	1.33273880	.1886585	33.3602	241.2648	144.5386	97.4731
37522.04030000	1.33274960	.1886274	33.3622	275.6882	121.4591	64.0718
37529.07080000	1.33273430	.1887117	33.3609	310.1348	98.3707	36.2700
37536.28190000	1.33273870	.1888820	33.3581	345.4404	74.6870	9.0038
37543.13060000	1.33272870	.1891593	33.3536	18.9422	52.1832	346.4884X
37550.07500000	1.33273170	.1893656	33.3501	52.8376	29.3801	324.2267
37557.01530000	1.33272910	.1894656	33.3493	86.6786	6.5821	296.5466
37564.04310000	1.33271750	.1893543	33.3511	120.9673	343.4963	258.1173
37571.06940000	1.33271720	.1890880	33.3519	155.2623	320.4175	214.1840
37578.00420000	1.33271280	.1888134	33.3552	189.1746	297.6414	164.4972
37585.03040000	1.33270580	.1885637	33.3577	223.5681	274.5616	120.7328
37592.05330000	1.33270600	.1884543	33.3593	257.9916	251.4825X	82.6611X
37599.08750000	1.33271720	.1884101	33.3598	292.4319	228.4019	50.2095
37606.02770000	1.33272050	.1885289	33.3566	326.4277	205.6114	23.2350
37613.02360000	1.33265570	.1887075	33.3498	1.2854X	182.2281X	356.8670X
37620.00000000	1.33268370	.1890043	33.3464	34.7781	159.7237	335.6011
37627.03056000	1.33266410	.1891840	33.3412	65.1077	136.6239	309.4771
37634.05970000	1.33267920	.1892017	33.3430	103.3821	113.5297	277.9536
37641.17640000	1.33266380	.1890120	33.3505	138.1212	90.1496	235.7752
37648.02220000	1.33266030	.1887096	33.3566	171.5643	67.6649	193.0739
37655.04720000	1.33265630	.1884531	33.3614	205.9580	44.5979	145.3806

Table 1b (Continued)

TIME (MJD)	A (e.r.)	E	INCL (DEG'S.)	OMEGA (DEG'S.)	NODE (DEG'S.)	MEAN ANOM. (DEG'S.)
37662.07220000	1.33265510	.1882510	33.3621	240.3630	21.5290	97.7260
37669.28060000	1.33266670	.1882166	33.3642	275.6804	357.8623	61.7806
37676.04030000	1.33264980	.1882481	33.3631	308.8047	335.6641	35.8259
37683.07080000	1.33266030	.1884697	33.3605	343.2391	312.5811	10.7756
37690.28190000	1.33261340	.1887299	33.3509	18.5287	288.9013	346.4631
37697.31250000	1.33263150	.1890071	33.3455	52.8539	265.8053	321.9315
37704.07220000	1.33260400	.1891149	33.3420	85.8441	243.5955	296.8415
37711.10000000	1.33261330	.1890206	33.3426	120.1283	220.5042	261.6244
37718.37710000	1.33260680	.1887608	33.3474	155.7717X	196.5351X	216.3240X
37726.05000000	1.33259540	.1884439	33.3537	193.2082	171.3941	161.3244
37733.07500000	1.33257980	.1882851	33.3580	227.6278	148.3236	115.8753
37740.01110000	1.33257220	.1882206	33.3596	261.6148	125.5424	75.9543
37747.40000000	1.33258170	.1882799	33.3585	297.8335	101.2702	43.2836
37754.06940000	1.33253960	.1883879	33.3563	330.5086	79.3599	20.0059
37761.00970000	1.33253430	.1886698	33.3539	4.4823	56.5590	358.0155
37768.21940000	1.33253260	.1889563	33.3504	39.7267	32.8746	331.7145
37775.15830000	1.33250340	.1891580	33.3483	73.5910	10.0757	305.0169
37783.26670000	1.33249100	.1891437	33.3480	113.1629	343.4262	266.2726
37790.02220000	1.33247810	.1889744	33.3496	146.1342	321.2277	228.7380
37797.04580000	1.33247070	.1887133	33.3541	180.4825	298.1464	181.2134
37804.15370000	1.33246250	.1884728	33.3600	215.3103X	274.7752X	128.8071X
37811.18330000	1.33245070	.1883967	33.3599	249.7420	251.6948	87.4780
37818.03060000	1.33244800	.1883543	33.3594	283.2963	229.1963	56.7958
37825.23890000	1.33244380	.1884626	33.3550	318.6285	205.5048	27.5673
37832.35830000	1.33247170	.1886858	33.3506	353.5044	182.1108	3.7078
37839.51940000	1.33240100	.1889568	33.3471	28.3407X	158.7110X	340.0747X
37846.23610000	1.33244730	.1891887	33.3450	61.3546	136.4936	315.3730
37853.08330000	1.33243560	.1892867	33.3455	94.7671	113.9863	285.6604
37860.01940000	1.33242710	.1891747	33.3487	128.6234	91.1846	250.8955
37867.04310000	1.33240940	.1889273	33.3543	162.9326	68.0971	205.5602
37874.06530000	1.33239220	.1886395	33.3605	197.3136	45.0177	154.8537
37881.08890000	1.33239610	.1884454	33.3648	231.7266	21.9365	109.8415
37888.20420000	1.33239260	.1883868	33.3660	266.6063	358.5553	70.7903
37895.05140000	1.33240030	.1883871	33.3642	300.1706	336.0550	41.8641
37902.44030000	1.33240390	.1885764	33.3610	336.3826	311.7719	15.1551
37909.37920000	1.33240360	.1888069	33.3547	10.3585	288.9680	352.3797
37916.13750000	1.33237440	.1890677	33.3488	43.3983	266.7513	329.1064
37923.16530000	1.33238340	.1892121	33.3457	77.7238	243.6417	301.5326
37930.10140000	1.33237850	.1891764	33.3461	111.5700	220.8372	268.1942
37937.03610000	1.33237140	.1889643	33.3516	145.4472	198.0389	229.4203
37944.05830000	1.33236530	.1886530	33.3555	179.7974	174.9562	180.1127
37951.06060000	1.33235010	.1884309	33.3591	214.2089	151.8774	130.9255
37958.01530000	1.33234520	.1882890	33.3610	248.2026	129.0847	92.5291
37965.22080000	1.33235460	.1883134	33.3619	283.5429	105.4001	55.2962
37972.15830000	1.33235220	.1883963	33.3629	317.5468	82.6005	28.1765
37979.00690000	1.33235190	.1886234	33.3609	351.1043	60.0906	6.3405
37986.30560000	1.33233190	.1888628	33.3571	26.8248	36.1025	340.9922
37993.42360000	1.33235680	.1891355	33.3531	61.5918	12.7056	315.0499
38000.09030000	1.33233190	.1891865	33.3515	94.1529	350.7847	287.2729
38007.02500000	1.33232920	.1891082	33.3538	128.0050	327.9857	249.6060
38014.04860000	1.33232990	.1888638	33.3577	162.3470	304.8959	206.8161
38021.07080000	1.33233530	.1885873	33.3611	196.7137	281.8159	158.5302
38028.00280000	1.33234000	.1884301	33.3623	230.6808	259.0340	109.7733
38035.02770000	1.33233980	.1883346	33.3621	265.1217	235.9442	72.4411
38042.23470000	1.33233590	.1884105	33.3602	300.4531	212.2558	41.4151
38049.35280000	1.33232680	.1885506	33.3588	335.3496	188.8573	15.5946
38056.02080000	1.33232410	.1888018	33.3548	8.0071	166.9372	353.5254
38063.31940000	1.33232590	.1890766	33.3504	43.7070	142.9408	328.6016
38070.16670000	1.33232850	.1892594	33.3496	77.1366	120.4296	301.8319
38077.01250000	1.33232330	.1892573	33.3512	110.5608	97.9171	269.5379
38084.03610000	1.33232400	.1890645	33.3539	144.8659	74.8247	226.9325
38091.05830000	1.33232630	.1887843	33.3596	179.2117	51.7367	178.7472
38098.17080000	1.33234010	.1885443	33.3644	214.0384	28.3594	130.7928
38105.01530000	1.33233590	.1884451	33.3672	247.5866	5.8642	92.7024
38112.13060000	1.33233720	.1883833	33.3675	282.4721	342.4831	55.7253
38119.06810000	1.33233360	.1885267	33.3626	316.4805	319.6889X	29.0994
38126.45690000	1.33233310	.1887152	33.3597	352.6793	295.3962	4.3911
38133.03470000	1.33231310	.1889617	33.3527	24.8672	273.7702	341.8879
38140.15280000	1.33233820	.1891881	33.3489	59.5378	250.3647	316.1196
38147.09020000	1.33233460	.1892242	33.3479	93.4926	227.5519	289.6278
38154.02500000	1.33233000	.1890778	33.3502	127.3572	204.7532	252.0584
38161.04720000	1.33232690	.1887773	33.3511	161.6865	181.6701	203.7764
38168.06940000	1.33233210	.1885076	33.3533	196.0669	158.5857	155.4157
38175.00280000	1.33232960	.1882938	33.3564	230.0448	135.7940	112.1818
38182.02770000	1.33232890	.1882247	33.3602	264.4876	112.7054	74.8950
38189.01250000	1.33234090	.1882292	33.3632	298.9408X	89.6147X	43.1914X
38196.08190000	1.33235380	.1883934	33.3613	333.3817	66.5227	17.0800
38203.02080000	1.33235400	.1886008	33.3572	7.3651	43.7194	356.1778
38210.04860000	1.33230060	.1888099	33.3513	41.7160	20.6216	330.1368
38217.07640000	1.33231920	.1889815	33.3483	76.0430	357.5176	304.1323
38224.01250000	1.33232160	.1889152	33.3486	109.8922	334.7184	272.2903
38231.03610000	1.33232740	.1887136	33.3515	144.2092	311.6322	229.7370
38238.05830000	1.33232240	.1884113	33.3540	178.5567	288.5545	181.5936
38245.17080000	1.33232250	.1882012	33.3540	213.3961	265.1796	133.7755
38252.01390000	1.33231940	.1880606	33.3557	246.9471	242.6902	90.4477
38259.04030000	1.33231340	.1880377	33.3547	281.3978	219.5952	59.0449
38266.33750000	1.33230800	.1880918	33.3553	317.1861	195.6168	28.8721
38273.00560000	1.33232220	.1882878	33.3525	349.8621	173.7000	7.2560
38280.12360000	1.33232800	.1885691	33.3469	24.7084	150.3082	342.0830
38287.24170000	1.33229760	.1888168	33.3432	59.4917	126.9083	317.0539
38294.26810000	1.33230200	.1889007	33.3426	93.8050	103.8057	286.3385
38301.08940000	1.33228750	.1887826	33.3444	127.2211X	81.3057X	249.6067X
38308.04580000	1.33228840	.1885688	33.3500	161.1190	58.5117	207.7894
38315.06670000	1.33228300	.1882687	33.3566	195.4839	35.4364	155.3100
38322.09030000	1.33226540	.1881288	33.3613	229.9108	12.3563	114.2025
38329.02360000	1.33225570	.1880518	33.3619	263.9132	349.5707	73.0303
38336.05000000	1.33225060	.1881229	33.3586	298.3649	326.4754	43.6458
38343.42590000	1.33222770	.1882691	33.3544	334.5970X	302.1943X	16.1249X
38350.01530000	1.33223630	.1885452	33.3504	6.8094	280.5666	356.2871
38357.40280000	1.33221860	.1888677	33.3430	42.9380	256.2807	329.3339

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Table 1b (Continued)

TIME (MJD)	A (e.r.)	E	INCL (DEG'S)	OMEGA (DEG'S.)	NODE (DEG'S.)	MEAN ANOM. (DEG'S.)
38364.06940000	1.33224290	.1890459	33.3416	75.4874	234.3596	304.9032
38371.00410000	1.33222890	.1890407	33.3396	109.3499	211.5515	270.8312
38378.16670000	1.33220950	.1888115	33.3402	143.6613 X	188.4539 X	231.7401 X
38385.04860000	1.33220860	.1885578	33.3457	178.0137	165.3642	181.5490
38392.15970000	1.33221040	.1882899	33.3519	212.8680	141.9805	131.8222
38399.00280000	1.33220620	.1881985	33.3564	246.4287	119.4854	92.0516
38406.74720000	1.33217870	.1881853	33.3577	284.4192	94.0267	51.1773
38413.05420000	1.33219360	.1883145	33.3567	315.3439	73.2925	31.3351
38430.08190000	1.33218770	.1889216	33.3470	38.7237	17.2992	334.4366
38434.04580000	1.33218560	.1890397	33.3457	58.0989	4.2640	320.3200
38441.07080000	1.33219010	.1890891	33.3446	92.3946	341.1614	287.8939
38448.18410000	1.33217060	.1889897	33.3445	127.1437	317.7642	250.4623 X
38469.06940000	1.33216490	.1882337	33.3509	229.4007	249.0827	113.8304
38476.00280000	1.33216110	.1881533	33.3518	263.4100	226.2846	75.6520
38483.02780000	1.33217190	.1881714	33.3535	297.8811	203.1864	43.5608
38490.14440000	1.33216440	.1883088	33.3491	332.7771	179.7879	17.5849
38497.08190000	1.33216540	.1885342	33.3445	6.7804	156.9748	356.3511
38504.19860000	1.33216020	.1887957	33.3393	41.6026	133.5663	330.6612
38511.44440000	1.33214960	.1889608	33.3365	75.0650 X	111.0468 X	303.5337 X
38518.06940000	1.33215430	.1889299	33.3392	109.3747	87.9399	271.9805
38525.09170000	1.33215910	.1887574	33.3435	143.6897	64.8452	229.3736
38532.11250000	1.33215820	.1881720 X	33.3483	178.0657 X	41.7576	181.1557
38539.04310000	1.33215610	.1873837 X	33.3668 X	212.1216 X	18.9379 X	132.4016
38546.15560000	1.33214370	.1880374	33.3557	246.8997	355.5901	90.0890
38553.00000000	1.33215520	.1880127	33.3554	280.4723	333.0904	57.6032
38560.55830000	1.33215410	.1881506	33.3521	322.4778 X	304.9497 X	28.1247 X
38567.41390000	1.33214070	.1883386	33.3475	351.1806	285.6970	7.4338
38574.35000000	1.33214890	.18864[illegible]	33.3407	25.1494	262.8907	341.0547
38581.01670000	1.33214330	.1888640	33.3367	57.7366	240.9631	318.9138
38588.13190000	1.33214330	.1889669	33.3319	92.5004	217.5553	287.9681
38595.06530000	1.33214390	.1888354	33.3340	126.3759	194.7475	250.5997
38602.08750000	1.33215130	.1885981	33.3390	160.7191	171.6499	208.0981

Measurement Residuals (rms)

A (e.r.)	E	INCL (DEG'S)	OMEGA (DEG'S.)	NODE (DEG'S.)	MEAN ANOM. (DEG'S.)
0.10600-04	0.15400-04	0.71600-03	0.91500-02	0.46400-02	0.97700+00

Table 1c
Observations – ARC 3
(Vanguard 2 Rocket From Routine NAVSPASUR Tracking)

TIME (MJD)	A (e.r.)	E	INCL (DEG'S)	OMEGA (DEG'S.)	NODE (DEG'S.)	MEAN ANOM. (DEG'S.)
39132.93794670	1.33085870	.1825930	32.9098	356.5535	168.4020	2.3463
39139.95482030	1.33085939	.1828841	32.9062	31.3286	145.2346	338.4127
39146.97107150	1.33085934	.1829387	32.9049	66.0802	122.0692	312.0181
39153.98597460	1.33085880	.1830364	32.9069	100.8244	98.9109	280.2504
39160.99896350	1.33085925	.1827602	32.9094	135.3234	75.7534	240.9677
39167.92021770	1.33086078	.1827880	32.9170	169.7286	52.9153	194.5909
39178.97595930	1.33086286	.1817973	32.9227	224.5836	16.4173	119.2453
39181.94275340	1.33086405	.1817958	32.9247	239.3281	6.6328	101.4656
39188.95665890	1.33086617	.1819110	32.9249	274.2464	343.4949	65.2514
39194.98284960	1.33086808	.1822952	32.9223	304.2583	323.6115	39.7598
39202.98900080	1.33087053	.1826515	32.9161	343.9117	297.1760	10.9745
39209.91605300	1.33087204	.1825878	32.9098	18.1890	274.3194	347.5876
39215.94326180	1.33087320	.1832400	32.9050	47.9443	254.3991	326.3011
39223.94834980	1.33087363	.1829499	32.9026	87.6636	227.9926	293.0941
39229.97319200	1.33087287	.1828451	32.9020	117.4558	208.1076	262.3382
39236.98526840	1.33087001	.1829727	32.9070	152.2797	184.9628	218.8191
39243.99601460	1.33086435	.1822807	32.9107	186.8814	161.8255	170.2203
39251.99591920	1.33085885	.1822347	32.9156	226.5955	135.4177	116.6891
39257.92994170	1.33085745	.1820060	32.9186	256.0507	115.8291	83.0824
39264.94467570	1.33085537	.1819171	32.9183	290.9491	92.6827	50.5535
39272.95030940	1.33085368	.1815037	32.9174	330.6189	66.2912	20.2792
39279.96714090	1.33085014	.1820147	32.9147	5.5734	43.1238	356.2131
39285.99434370	1.33084961	.1823160	32.9128	35.4611	23.2379	335.4286
39292.92044970	1.33084753	.1826300	32.9103	69.6967	0.3752	308.9821
39299.93506780	1.33084493	.1826243	32.9084	104.4471	337.2194	276.4671
39301.91319870	1.33084351	.1826131	32.9083	114.2440	330.6914	265.9158
39302.99210910	1.33084297	.1826037	32.9084	119.5845	327.1346	259.8821
39305.95884660	1.33084171	.1825860	32.9080	134.3176	317.3463	242.2105
39306.94767350	1.33084256	.1826297	32.9093	139.2748	314.0872	235.9430
39315.93579270	1.33083359	.1821079	32.9135	183.6643	284.4088	174.7899
39321.95771070	1.33083147	.1824060	32.9161	213.5252	264.5384	133.4534
39327.98078830	1.33082259	.1817747	32.9177	243.4274	244.6556	96.7905
39334.99456180	1.33081979	.1817388	32.9169	278.1637	221.5337	61.6889
39341.91998130	1.33081468	.1812559	32.9163	312.4032	198.6876	33.5861
39348.93628820	1.33080727	.1817304	32.9109	347.5115	175.5166	8.5241
39355.95277210	1.33080149	.1820869	32.9097	22.3615	152.3554	344.6816
39362.96876890	1.33079261	.1827479	32.9075	57.0022	129.1760	319.2987
39369.98352200	1.33078206	.1827036	32.9067	91.7562	106.0265	289.1851
39376.99637210	1.33077381	.1826585	32.9095	126.5165	82.8863	251.7600
39383.91735120	1.33077058	.1823779	32.9135	160.7509	60.0418	207.1628
39390.92719670	1.33076311	.1822104	32.9178	195.5331	36.8931	158.0244
39397.93779550	1.33075358	.1818314	32.9215	230.3489	13.7509	112.1143
39404.95023950	1.33074463	.1818878	32.9239	265.1414	350.6135	73.9263
39411.96449760	1.33073561	.1819054	32.9228	300.0925	327.4586	43.0815
39418.97985270	1.33072083	.1818813	32.9173	334.8430	304.3131	17.2879
39425.99563010	1.33070933	.1824508	32.9130	9.6982	281.1447	353.4066
39432.92118130	1.33069777	.1827166	32.9084	44.0370	258.2693	329.1864
39439.93571520	1.33068830	.1828738	32.9044	78.6867	235.0975	301.2557
39446.94857180	1.33067905	.1827351	32.9033	113.3723	211.9276	266.8957
39453.95932670	1.33066935	.1824919	32.9057	148.1279	188.7718	224.3600

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OF POOR QUALITY

Table 1c (Continued)

TIME (MJD)	A (e.r.)	E	INCL (DEG'S)	OMEGA (DEG'S.)	NODE (DEG'S.)	MEAN ANOM. (DEG'S.)
39460.96853620	1.33066102	.1821295	32.9099	182.8834	165.6253	175.8993
39467.97784270	1.33065398	.1819455	32.9160	217.7190	142.4862	127.9964
39474.98874960	1.33064248	.1817257	32.9203	252.6103	119.3386	86.7429
39486.94737640	1.33062631	.1821179	32.9208	312.0959	79.8468	33.7574
39489.91509930	1.33062305	.1821679	32.9213	326.8292	70.0473	22.9454
39496.93004430	1.33061471	.1823035	32.9182	1.6189	46.8911	358.9049
39503.94489410	1.33060459	.1827451	32.9137	36.3718	23.7147	334.7953
39505.92333180	1.33060234	.1828968	32.9123	46.1484	17.1774	327.6253
39507.45207110	1.33060084	.1828944	32.9085	53.7524	12.1536	321.8433
39510.95896260	1.33059933	.1829073	32.9117	71.0879	0.5532	307.8358
39517.97153840	1.33059429	.1828571	32.9104	105.8290	337.3946	275.0461
39524.98207700	1.33058754	.1827308	32.9121	140.5345	314.2423	234.3335
39531.99084580	1.33057851	.1824410	32.9143	175.2542	291.0921	186.7494
39538.99930850	1.33057079	.1819931	32.9174	210.0009	267.9374	138.1782
39545.91924440	1.33056409	.1819125	32.9186	244.4018	245.0923	95.6805
39552.93100920	1.33055650	.1818472	32.9173	279.3085	221.9268	60.6471
39559.94433210	1.33054603	.1820834	32.9156	314.1725	198.7593	32.1995
39573.97287330	1.33053117	.1826549	32.9097	23.7969	152.4293	343.7014
39580.98667850	1.33051992	.1828373	32.9046	58.4948	129.2485	318.1294
39587.99921200	1.33050996	.1827923	32.9043	93.1687	106.0929	287.8318
39594.91996260	1.33050374	.1826113	32.9066	127.5024	83.2223	250.5720
39601.92860720	1.33049718	.1822884	32.9121	162.2453	60.0621	205.0806
39608.93628160	1.33048878	.1821041	32.9198	197.0624	36.9216	155.8923
39615.94479570	1.33048312	.1818493	32.9229	231.9286	13.7763	110.1982
39622.95521850	1.33048100	.1819047	32.9231	266.7724	350.6245	72.3335
39629.96747890	1.33048032	.1819995	32.9221	301.6255	327.4684	41.8548
39636.98090920	1.33047598	.1822349	32.9186	336.5122	304.2950	16.1080
39643.99474920	1.33046852	.1824534	32.9148	11.3226	281.1339	352.2974
39650.91843770	1.33046786	.1826912	32.9106	45.6464	258.2687	327.9866
39657.93113140	1.33046866	.1828620	32.9075	80.3731	235.0930	299.7541
39664.94220330	1.33046972	.1828354	32.9057	115.0555	211.9226	265.0378
39671.95124590	1.33046988	.1826759	32.9094	149.8006	188.7727	222.1385
39678.95886780	1.33047016	.1824082	32.9114	184.5466	165.6214	173.5327
39685.96675010	1.33047102	.1820667	32.9150	219.3381	142.4669	125.8917
39692.97635050	1.33047148	.1818663	32.9182	254.1793	119.3225	85.0666
39706.91101590	1.33046898	.1819693	32.9171	323.4651	73.2918	25.3750
39713.92474190	1.33046854	.1822370	32.9135	358.3296	50.1163	1.1407
39720.93850390	1.33046868	.1825058	32.9107	33.1309	26.9455	337.1102
39727.95159450	1.33046519	.1827008	32.9092	67.8673	3.7706	310.5176
39734.96327550	1.33045940	.1827740	32.9089	102.5212	340.6070	278.4813
39741.97293320	1.33045213	.1826744	32.9115	137.2683	317.4501	238.5047
39748.98074700	1.33044498	.1825196	32.9154	172.0174	294.3011	191.3443
39755.98808260	1.33043723	.1822239	32.9181	206.8027	271.1492	142.4752
39762.99667320	1.33042877	.1818167	32.9219	241.5833	248.0008	98.8752
39769.91731860	1.33042113	.1816450	32.9226	276.0042	225.1444	63.6629
39776.92946060	1.33041094	.1816022	32.9215	310.9020	201.9846	34.6977
39783.94250400	1.33040058	.1816851	32.9171	345.7496	178.8237	9.7339
39790.95573340	1.33038601	.1819646	32.9111	20.5909	155.6524	345.9078
39797.96841800	1.33036536	.1823426	32.9086	55.3556	132.4686	320.5547
39804.97986860	1.33035509	.1824826	32.9066	89.9992	109.2880	290.8389
39811.98943750	1.33034533	.1823912	32.9085	124.7920	86.1394	253.7840
39818.99693170	1.33032926	.1821338	32.9153	159.4903	62.9883	208.8964
39825.91343410	1.33031184	.1818762	32.9213	193.8217	40.1418	160.4359
39832.92038380	1.33030039	.1815869	32.9252	228.6412	16.9985	114.2280
39839.92913650	1.33028563	.1813614	32.9258	263.5181	353.8491	75.5873
39846.93957380	1.33025129	.1813851	32.9241	298.4047	330.6858	44.4796
39853.95102540	1.33022480	.1815272	32.9201	333.3301	307.5201	18.3640
39860.96278640	1.33019637	.1817376	32.9134	8.1831	284.3504	354.4310
39867.97414090	1.33016308	.1818751	32.9063	43.0094	261.1837	329.8935
39874.98437510	1.33013222	.1821508	32.9012	77.7465	238.0145	302.0103
39881.99285090	1.33011413	.1822016	32.8989	112.4709	214.8342	267.8266
39888.99910340	1.33007721	.1820317	32.9032	147.1194	191.6533	225.6640
39895.91372130	1.33003493	.1814805	32.9075	181.4031	168.7897	178.0068
39902.91794720	1.33000782	.1814455	32.9135	216.2745	145.6491	129.9200
39909.92359740	1.32998261	.1814129	32.9182	251.1587	122.4834	88.3302
39916.93102900	1.32994793	.1813910	32.9193	286.1098	99.3124	54.7165
39923.93968100	1.32991369	.1815658	32.9185	321.0411	76.1343	27.1586
39928.97191750	1.32989818	.1816651	32.9171	346.0580	59.4901	9.5225
39930.94889320	1.32989110	.1817439	32.9159	355.8801	52.9496	2.8094
39930.94889340	1.32989093	.1817606	32.9159	355.8832	52.9493	2.8072
39932.92586200	1.32988468	.1818343	32.9148	5.6936	46.4116	356.1298
39934.99266850	1.32987823	.1818999	32.9130	15.9768	39.5716	349.0937
39935.98112640	1.32987506	.1819227	32.9110	20.8780	36.3040	345.7070
39937.95800650	1.32986789	.1820254	32.9108	30.6964	29.7625	338.8215
39939.93482000	1.32986045	.1821084	32.9105	40.5120	23.2147	331.7477
39940.92319480	1.32985540	.1821157	32.9100	45.4118	19.9468	328.1231
39944.96628330	1.32983281	.1822119	32.9059	65.4260	6.5751	312.4889
39951.97292890	1.32979707	.1823205	32.8990	100.2370	343.3809	280.7643
39958.97742430	1.32977626	.1821855	32.9011	135.0342	320.2452	241.2743
39965.97994530	1.32975548	.1817084	32.9038	169.6514	297.0522	194.6706
39972.98177020	1.32973999	.1815418	32.9072	204.4934	273.8845	145.6620
39979.98467560	1.32972450	.1814525	32.9093	239.3687	250.7137	101.4571
39986.98948430	1.32971007	.1813462	32.9101	274.2970	227.5411	65.2665
39993.99591050	1.32970010	.1814821	32.9073	309.1981	204.3559	36.0045
40000.91344340	1.32968833	.1818003	32.9033	343.6653	181.4584	11.1654
40007.92102140	1.32967382	.1819057	32.8983	18.5225	158.2694	347.3382
40014.92812900	1.32965949	.1821651	32.8944	53.3318	135.0656	322.1118
40021.93404150	1.32964406	.1823083	32.8944	88.1220	111.8746	292.5928
40028.93809480	1.32963400	.1822665	32.8970	122.8270	88.6809	256.0844
40033.96533580	1.32962850	.1822315	32.8997	147.8358	72.0475	224.7286
40035.94007250	1.32962630	.1821519	32.9012	157.6359	65.5110	211.4556
40038.99176930	1.32962300	.1819754	32.9023	172.7738	55.4150	190.2614
40042.94088890	1.32961951	.1818520	32.9069	192.4125	42.3404	162.4165
40049.94231440	1.32961337	.1814449	32.9125	227.2697	19.1697	115.9328
40056.94556670	1.32960852	.1813739	32.9139	262.1358	355.9953	76.9617
40063.95069590	1.32960444	.1814751	32.9128	297.1285	332.8077	45.5028
40069.96894390	1.32960042	.1816857	32.9109	327.1385	312.8862	22.7480
40070.95706990	1.32960000	.1817134	32.9103	332.0583	309.6141	19.2523
40077.96396270	1.32959610	.1819707	32.9059	6.8873	286.4246	355.3176
40084.97069390	1.32959127	.1822170	32.9000	41.6674	263.2370	330.9056

Table 1c (Continued)

TIME (MJD)	A (e.r.)	E	INCL (DEG'S.)	OMEGA (DEG'S.)	NODE (DEG'S.)	MEAN ANOM. (DEG'S.)
40091.97654010	1.32958471	.1822831	32.8957	76.4544	240.0384	303.1577
40098.98079650	1.32958097	.1822459	32.8949	111.2210	216.8442	269.1990
40105.98300340	1.32957479	.1820284	32.8991	145.9628	193.6668	227.1933
40110.91940250	1.32956865	.1819369	32.9025	170.5237	177.3296	193.4447
40112.98359350	1.32956531	.1818159	32.9046	180.7693	170.4952	178.9058
40115.94526240	1.32956145	.1817349	32.9068	195.5114	160.6901	158.0740
40119.98416660	1.32955787	.1815198	32.9092	215.6156	147.3174	130.7747
40126.98629990	1.32955327	.1813820	32.9111	250.5267	124.1458	89.0131
40133.99039730	1.32954800	.1813901	32.9111	285.4265	100.9664	55.3063
40140.99596700	1.32954293	.1815698	32.9103	320.3328	77.7738	27.6758
40147.91246640	1.32953713	.1817378	32.9092	354.7726	54.8782	3.5639
40154.91886250	1.32953356	.1821481	32.9062	29.5842	31.6739	339.6160
40157.97277720	1.32953084	.1822079	32.9061	44.7565	21.5613	328.6179
40161.92461920	1.32952452	.1822430	32.9041	64.3918	8.4788	313.3384
40168.92898280	1.32951521	.1822649	32.9031	99.1631	345.2893	281.8442
40175.93140390	1.32951219	.1821798	32.9057	133.8515	322.1064	242.7515
40182.93193690	1.32951189	.1819508	32.9058	168.6761	298.9170	196.0529
40189.93188520	1.32951174	.1816649	32.9079	203.5181	275.7453	146.9885
40196.93299540	1.32951100	.1815262	32.9108	238.3933	252.5773	102.5788
40203.93609350	1.32950800	.1814498	32.9093	273.3187	229.3895	66.1634
40210.94091250	1.32950520	.1814976	32.9065	308.2239	206.2052	36.7502
40217.94674450	1.32949966	.1817187	32.9027	343.1296	183.0111	11.5365
40224.95286120	1.32949342	.1818152	32.8976	18.0142	159.8174	347.6869
40231.95859580	1.32949009	.1821138	32.8945	52.8204	136.6136	322.5026
40238.96323710	1.32948647	.1822648	32.8957	87.5595	113.4109	293.1152
40245.96610030	1.32948440	.1822081	32.8980	122.3230	90.2168	256.6672
40252.96693200	1.32948004	.1821115	32.9029	157.1315	67.0413	212.1465
40259.96659600	1.32947215	.1817019	32.9089	191.9003	43.8627	163.1419
40266.96683450	1.32946639	.1814315	32.9142	226.7569	20.6908	116.5571
40273.96890370	1.32946269	.1813052	32.9171	261.6578	357.5135	77.4483
40280.97281130	1.32945126	.1813233	32.9177	296.5279	334.3243	46.0041
40287.97793800	1.32944169	.1814853	32.9151	331.4809	311.1308	19.6698
40294.98355640	1.32943419	.1815736	32.9082	6.3404	287.9389	355.6863
40301.98898140	1.32942100	.1818942	32.8999	41.1469	264.7354	331.2685

Measurement Residuals (rms)

A (e.r.)	E	INCL (DEG'S,)	OMEGA (DEG'S.)	NODE (DEG'S.)	MEAN ANOM. (DEG'S.)
0.1250D-04	0.2240D-03	0.1660D-02	0.1630D-00	0.4430D-01	0.1810D+01

Table 1d
Observations – ARC 4
(Vanguard 2 Rocket From Routine NAVSPASUR Tracking)

TIME (MJD)	A (e.r.)	MEAN ANOM. (DEG'S.)	INCL (DEG'S.)	OMEGA (DEG'S.)	NODE (DEG'S.)	MEAN ANOM. (DEG'S.)
40308.99342030	1.32939734	.1818802	32.8972	75.9795	241.5491	303.5307
40315.99618700	1.32938141	.1818819	32.8973	110.6505	218.3602	269.7771
40322.99681260	1.32936650	.1816978	32.8992	145.3883	195.1602	227.9230
40329.99574230	1.32935103	.1815579	32.9018	180.2787	171.9903	179.6032
40336.99459220	1.32933879	.1812039	32.9027	215.1623	148.8113	131.3951
40343.99493850	1.32932723	.1810535	32.9041	250.0537	125.6380	89.5617
40350.99721060	1.32931974	.1810546	32.9040	284.9545	102.4467	55.7493
40357.91110670	1.32930200	.1810839	32.9030	319.4458	79.5425	28.3553
40364.91545160	1.32928319	.1812632	32.9010	354.3361	56.3550	3.8655
40371.91978450	1.32926867	.1815391	32.8999	29.2270	33.1524	339.8417
40378.92343920	1.32925659	.1816281	32.8985	64.0552	9.9662	313.5574
40385.92562910	1.32922879	.1817017	32.8979	98.8658	346.7660	282.0784
40392.92569220	1.32920075	.1816014	32.8998	133.5684	323.5797	243.0460
40399.92373590	1.32918605	.1813816	32.9049	168.3536	300.3987	196.4900
40406.92106990	1.32917196	.1810869	32.9094	203.1819	277.2306	147.4834
40413.91941760	1.32915484	.1809032	32.9104	238.0839	254.0437	103.0079
40420.91964750	1.32914238	.1808420	32.9097	273.0222	230.8573	66.5073
40427.92156480	1.32913741	.1809999	32.9070	308.0075	207.6638	36.9544
40434.92445090	1.32912873	.1809298	32.9038	342.8408	184.4668	11.7566
40441.92757360	1.32910682	.1813466	32.9004	17.7134	161.2637	347.8819
40448.93017480	1.32908655	.1816586	32.8968	52.5496	138.0454	322.6764
40455.93160350	1.32907587	.1817498	32.8974	87.3896	114.8600	293.2167
40462.93118240	1.32905848	.1816545	32.8971	122.0589	91.6468	256.9136
40469.92854740	1.32902876	.1816486	32.9030	156.9528	68.4599	212.3650
40476.92458540	1.32900694	.1814470	32.9098	191.7693	45.2922	163.3344
40483.92110100	1.32898708	.1809225	32.9163	226.6555	22.0973	116.7465
40490.91930640	1.32896543	.1807007	32.9217	261.5507	358.9106	77.6263
40497.91921490	1.32894164	.1808147	32.9203	296.4040	335.7156	46.1508
40504.92029060	1.32892687	.1810827	32.9162	331.3691	312.5154	19.7665
40511.92180460	1.32891099	.1815535	32.9110	6.2794	289.2998	355.7278
40518.92306490	1.32889291	.1817340	32.9056	41.1298	266.0819	331.2714
40525.92330610	1.32886373	.1818424	32.9016	75.9105	242.8699	303.5871
40532.92185050	1.32884958	.1818423	32.9004	110.6791	219.6715	269.7417
40539.91828250	1.32883816	.1816849	32.9022	145.4674	196.4746	227.8184
40546.91305890	1.32882667	.1814020	32.9059	180.2935	173.2667	179.5827
40553.99742200	1.32880940	.1812300	32.9116	215.6122	149.7904	130.8037
40560.99358820	1.32879370	.1809723	32.9154	250.5155	126.5929	89.0729
40567.99165020	1.32878388	.1809550	32.9168	285.4376	103.3920	55.3407
40574.99115980	1.32877454	.1810737	32.9162	320.4042	80.1764	27.6530
40581.99139840	1.32876587	.1815032	32.9139	355.3374	56.9569	3.1807
40588.99165020	1.32875786	.1814523	32.9109	30.2121	33.7582	339.1390
40595.99125850	1.32875156	.1816349	32.9078	65.0319	10.5487	312.7592
40602.98949890	1.32874479	.1817314	32.9065	99.7862	347.3344	281.1526
40609.98573950	1.32873450	.1816691	32.9083	134.5999	324.1351	241.7669
40616.98006800	1.32872604	.1816426	32.9127	169.4223	300.9612	194.9917
40619.93891240	1.32872320	.1816018	32.9146	184.1599	291.1509	174.0914
40623.97378240	1.32871775	.1813391	32.9143	204.2486	277.7571	146.0088
40630.96863010	1.32871026	.1810921	32.9163	239.0929	254.5599	101.8163
40637.96541570	1.32869972	.1808847	32.9158	274.0637	231.3561	65.5337
40644.96384070	1.32869175	.1809044	32.9154	308.9531	208.1579	36.2353

Table 1d (Continued)

TIME (MJD)	A (e.r.)	E	INCL (DEG'S.)	OMEGA (DEG'S.)	NODE (DEG'S.)	MEAN ANOM. (DEG'S.)
40651.96322640	1.32868145	.1811250	32.9120	343.8931	184.9454	11.0251
~~40658~~.96283750	1.32866841	.1812701	32.9086	18.8032	161.7294	347.1260
40665.96200780	1.32866106	.1815069	32.9054	53.6586	138.5121	321.8078
40672.96004590	1.32865486	.1816847	32.9038	88.4360	115.2942	292.2277
40679.95622740	1.32864359	.1817545	32.9058	123.3596	92.0959	255.4034
40686.95035020	1.32863244	.1816078	32.9101	158.1021	68.8890	210.7834
40693.94330410	1.32862300	.1812615	32.9167	192.8858	45.6868	161.7709
40700.93686820	1.32861564	.1809868	32.9217	227.7458	22.4964	115.3914
40707.93226090	1.32861211	.1808983	32.9242	262.6097	359.3047	76.5437
~~40714~~.92951590	1.32860778	.1808747	32.9222	297.5371	336.0975	45.2252
40721.92801090	1.32860397	.1810344	32.9181	332.4358	312.8798	18.9793
40728.927[illegible]230	1.32859660	.1812330	32.9122	7.3819	289.6644	354.9720
40735.92580760	1.32859079	.1814762	32.9097	42.2308	266.4557	330.4441
40742.92371650	1.32858416	.1816223	32.9075	77.0384	243.2404	302.5781
40749.92003330	1.32858152	.1815969	32.9066	111.8109	220.0332	268.4798
40756.91430210	1.32857391	.1814163	32.9083	146.5694	196.8296	226.3435
40763.99663290	1.32857108	.1812625	32.9108	181.8900	173.3255	177.3159
~~40770~~.98940930	1.32856967	.1810018	32.9130	216.7509	150.1310	179.3365
40777.98380270	1.32856746	.1808150	32.9154	251.6632	126.9323	87.8594
40784.98015970	1.32856472	.1808252	32.9161	286.5703	103.7268	54.3769
40791.97800090	1.32856374	.1810135	32.9123	321.4946	80.5091	26.8597
40798.97657840	1.32855810	.1810727	32.9117	356.4056	57.2996	2.4552
40805.97520470	1.32855566	.1813058	32.9091	31.2770	34.0817	338.3747
40819.96983640	1.32854842	.1815591	32.9084	100.8589	347.6378	280.0428
40826.96449240	1.32854392	.1813927	32.9093	135.6566	324.4411	240.4157
~~40833.95728200~~	1.32853736	.1812774	32.9118	170.5271	301.2635	193.4233
40840.94952970	1.32852818	.1808765	32.9141	205.3464	278.0693	144.5413
40847.94291990	1.32851975	.1808424	32.9153	240.2620	254.8612	100.4974
40854.93827580	1.32850919	.1805564	32.9152	275.2657	231.6617	64.4596
40861.93521160	1.32849655	.1805346	32.9151	310.1268	208.4609	35.3653
40868.93306380	1.32848458	.1807746	32.9107	345.0486	185.2469	10.2367
40875.93110140	1.32846811	.1809456	32.9054	19.9584	162.0275	346.3153
40889.92481010	1.32842270	.1811555	32.8994	89.6132	115.5883	291.0560
40896.91902620	1.32839160	.1809296	32.9002	124.3315	92.3699	254.1685
40903.91102060	1.32835900	.1806805	32.9069	159.1605	69.1866	209.2752
40910.99133960	1.32832674	.1805302	32.9159	194.5278	45.6857	159.4964
40917.98256090	1.32830081	.1803595	32.9211	229.4251	22.4900	113.3941
40924.97550340	1.32827930	.1803014	32.9233	264.3289	359.2996	74.9082
40931.97010680	1.32824712	.1802565	32.9218	299.3275	336.0899	43.8359
40938.96567150	1.32821376	.1805526	32.9176	334.2932	312.8688	17.7252

Measurement Residuals (rms)

A (e.r.)	E	INCL (DEG'S.)	OMEGA (DEG'S.)	NODE (DEG'S.)	MEAN ANOM. (DEG'S.)
0.9310D-05	0.1270D-03	0.1540D-02	0.4550D-01	0.1930D-00	0.2100D+01

Table 1e
Observations – ARC 5
(Vanguard 2 Rocket From Routine NAVSPASUR Tracking)

TIME (MJD)	A (e.r.)	E	INCL (DEG'S.)	OMEGA (DEG'S.)	NODE (DEG'S.)	MEAN ANOM. (DEG'S.)
40945.96152350	1.32819092	.1807195	32.9128	9.1892	289.6536	353.7297
~~40952~~.95704120	1.32817358	.1809629	32.9079	44.0393	266.4274	329.0702
40959.95154370	1.32815667	.1811125	32.9051 X	78.8547	243.2065	300.9220
40966.94433450	1.32814353	.1810973	32.9033	113.6738	219.9880	266.3723
40973.93500420	1.32812817	.1808473	32.9040	148.4498	196.7823	223.8058
40980.92410050	1.32811104	.1804510	32.9074 X	183.2741	173.5675	175.3589
40987.91319220	1.32808496	.1802551	32.9160	218.1456	150.3768	127.5923
40994.99341280	1.32806759	.1802719	32.9165	253.6232	126.8555	85.8399
41001.98588600	1.32805168	.1802826	32.9181	288.6182	103.6437	52.6795
~~41008.97965950~~	1.32803270	.1804300	32.9166	323.5533	80.4254	25.3953
41015.97400430	1.32801301	.1808223	32.9135	358.4739	57.1868	1.0458
41022.96823640	1.32799597	.1809646	32.9103	33.3646	33.9568	336.8655
41029.96167590	1.32797838	.1811679	32.9084	68.1782	10.7225	310.1132
41036.95360560	1.32796408	.1811985	32.9091	103.0275	347.4991	277.7743
41043.94349520	1.32795355	.1811004	32.9113	137.7857	324.2822	237.6990
41050.93153520	1.32794363	.1808342	32.9136	172.5970	301.0615	190.4898
41057.91911910	1.32793304	.1804703	32.9155	207.4765	277.8525	141.6818
~~41064.99752260~~	1.32791989	.1804169	32.9171	242.8821	254.3436	97.5611
41071.98827950	1.32791330	.1804035	32.9171	277.8633	231.1238	62.1042
41078.98064130	1.32790787	.1805875	32.9153	312.8506	207.8877	33.2951
41085.97390990	1.32790204	.1808446	32.9112	347.7843	184.6630	8.3536
41092.96737390	1.32789726	.1810114	32.9057	22.6895	161.4268	344.4103
41099.96036400	1.32789283	.1812404	32.9020	57.5304	138.1912	318.7526
41105.96623790	1.32788953	.1813403	32.9017	87.4184	118.2273	293.1391
41113.94208220	1.32788226	.1812005	32.9051	127.1323	91.7239	250.8630
~~41120.93002690~~	1.32787763	.1808547	32.9106	161.9233	68.4975	205.4618
41127.91704330	1.32787621	.1804674	32.9156	196.8122	45.2862	156.3137
41134.99451510	1.32787627	.1802919	32.9197	232.2106	21.7857	110.0238
41141.98432290	1.32787425	.1803283	32.9216	267.1498	358.5672	72.1459
41148.97595580	1.32787244	.1805005	32.9192	302.1693	335.3401	41.5465
41155.96874170	1.32786951	.1806806	32.9177	337.1590	312.1059	15.7071
41162.96196660	1.32786944	.1808827	32.9112	12.0391	288.8792	351.7733
41169.95496310	1.32786932	.1811751	32.9051	46.9054	265.6433	326.9333
~~41176.94701040~~	1.32786833	.1812378	32.9006	81.7457	242.4134	298.3417
41183.93740010	1.32786717	.1812261	32.9000	116.5666	219.1784	263.1545
41197.91275590	1.32786033	.1805231	32.9097	186.1895	172.7335	171.2317
41204.98965710	1.32786090	.1803124	32.9133	221.6028	149.2256	123.1538
41211.97873980	1.32786195	.1802745	32.9152	256.5737	126.0067	82.7511
41218.96976600	1.32786041	.1802356	32.9150	291.4896	102.7886	50.2589
41225.96218090	1.32785813	.1805311	32.9129	326.5293	79.5485	23.2383
41232.95524260	1.32785630	.1807895	32.9115	1.4695	56.3114	358.9980
~~41239~~.94828010	1.32785646	.1811077	32.9078	36.3405	33.0722	334.7227
41246.94060030	1.32785712	.1812909	32.9055	71.1683	9.8355	307.6038
41253.93147500	1.32785687	.1813013	32.9057	105.9890	346.6101	274.6915
41260.92036950	1.32785577	.1811307	32.9087	140.7704	323.3786	233.8844
41267.99712200	1.32785219	.1808316	32.9124	176.0723	299.8626	185.5705
41274.98407870	1.32785114	.1804579	32.9164	210.9824	276.6538	136.9809
41281.97247780	1.32785203	.1803468	32.9184	245.9550	253.4321	94.1284
41288.96288230	1.32785208	.1803805	32.9170	280.9033	230.2093	59.3758
~~41295.95487620~~	1.32785081	.1804646	32.9145	315.8273	206.9826	31.0680

Table 1e (Continued)

TIME (MJD)	A (e.r.)	E	INCL (DEG'S.)	OMEGA (DEG'S.)	NODE (DEG'S.)	MEAN ANOM. (DEG'S.)
41302.94773780	1.32784659	.1806031	32.9081	350.7992	183.7446	6.2855
41309.94074970	1.32784197	.1809832	32.9038	25.7188	160.5024	342.2877
41316.93324290	1.32784078	.1812495	32.8999	60.5437	137.2573	316.3568
41323.92450780	1.32784141	.1812586	32.8998	95.3701	114.0301	285.5011
41330.91391070	1.32784179	.1811966	32.9037	130.1884	90.8058	247.1655
41337.99096150	1.32783995	.1810297	32.9083	165.5169	67.2919	200.4593
41344.97765100	1.32783404	.1807349	32.9159	200.3519	44.0755	151.3949
41351.96535120	1.32783081	.1801941	32.9189	235.3083	20.8595	106.3405
41358.95499880	1.32783073	.1802077	32.9205	270.2702	357.6451	69.1669
41365.94639840	1.32782610	.1801270	32.9203	305.1816	334.4265	39.2090
41372.93882510	1.32781486	.1800683	32.9163	340.0932	311.1922	13.6816
41379.93158940	1.32780549	.1806043	32.9090	15.0688	287.9692	349.6833
41386.92399780	1.32779931	.1808849	32.9029	49.9081	264.7175	324.6377
41393.91535030	1.32779211	.1809373	32.9001	84.7564	241.4942	295.5644
41400.99450260	1.32777741	.1808333	32.9003	120.0470	217.9736	259.1474
41407.98192760	1.32776401	.1807753	32.9058	154.9062	194.7602	215.1083
41414.96805490	1.32775321	.1803949	32.9109	189.7477	171.5358	166.2117
41421.95459640	1.32774022	.1801816	32.9119	224.6703	148.3281	119.2946
41428.94284460	1.32772654	.1800175	32.9137	259.6301	125.1068	79.6442
41435.93294370	1.32771831	.1801009	32.9132	294.6823	101.8724	47.6224
41442.92428910	1.32771004	.1802054	32.9146	329.6105	78.6434	21.0502
41449.91616750	1.32770040	.1802744	32.9116	4.4931	55.4175	356.9315
41456.99748550	1.32768207	.1805767	32.9086	39.8873	31.8786	332.1077
41463.98825840	1.32767094	.1806895	32.9060	74.7390	8.6482	304.4819
41470.97746360	1.32766350	.1807427	32.9055	109.4585	345.4264	270.9295
41477.96457760	1.32765004	.1806427	32.9092	144.3295	322.2152	229.2231
41484.94998340	1.32763178	.1802021	32.9137	179.1618	298.9942	181.1879
41491.93520820	1.32761535	.1799688	32.9171	214.0955	275.7779	132.8978
41498.92187890	1.32760741	.1798866	32.9165	249.0946	252.5542	90.7366
41505.91048360	1.32759965	.1800296	32.9161	283.0271X	229.3287	56.6594
41512.99018810	1.32759079	.1801427	32.9140	319.4445	205.8048	28.4093
41519.98103980	1.32758449	.1803689	32.9103	354.3916	182.5663	3.8304
41526.97194630	1.32757641	.1806266	32.9067	29.3255	159.3185	339.7256
41533.96219080	1.32756346	.1808481	32.9029	64.1949	136.0708	313.3670
41540.95100900	1.32754567	.1810031	32.9032	98.9863	112.8437	281.8711
41547.93783070	1.32753733	.1809124	32.9062	133.8082	89.6047	242.6768
41554.92272440	1.32752491	.1805619	32.9119	168.6496	66.3845	196.0491
41561.99644770	1.32750758	.1805337	32.9171	203.9855	42.8621	146.4176
41568.98171930	1.32749338	.1798452	32.9209	238.9887	19.6412	102.0761
41575.96885340	1.32748532	.1801465	32.9223	273.9289	356.4143	65.7382
41582.95767960	1.32747785	.1802864	32.9220	308.9049	333.1844	36.3151
41589.94745010	1.32746826	.1804175	32.9179	343.8392	309.9370	11.0751
41596.93747280	1.32745954	.1806831	32.9115	18.7672	286.6967	347.1287
41603.92707140	1.32745196	.1809838	32.9060	53.6193	263.4534	321.7917
41610.91551810	1.32744449	.1810033	32.9030	88.5498	240.2072	292.0393
41617.99170050	1.32743393	.1808498	32.9050	123.7266	216.6621	254.8693
41624.97624620	1.32742393	.1805726	32.9081	158.5242	193.4349	210.1450
41631.95968930	1.32742196	.1800800	32.9104	193.4435	170.2058	161.0306
41638.94380740	1.32742189	.1801995	32.9133	228.3884	146.9912	114.6804
[illegible]	1.32741570	.1800480	32.9159	263.3310	123.[illegible]	

Table 1e (Continued)

TIME (MJD)	A (e.r.)	E	INCL (DEG'S.)	OMEGA (DEG'S.)	NODE (DEG'S.)	MEAN ANOM. (DEG'S.)
41652.91759080	1.32741044	.1801534	32.9152	298.3335	100.5188	44.6422
~~41659.99624450~~	1.32740737	.1804608	32.9158	333.8470	76.9761	18.0386
41666.98578410	1.32740437	.1806141	32.9123	8.7503	53.7336	354.0233
41673.97512360	1.32739888	.1808880	32.9106	43.6614	30.4880	329.3405
41680.[illegible]440	1.32739507	.1809834	32.9080	78.4865	7.2314	301.2295
41687.95037500	1.32739361	.1808899	32.9079	113.2828	343.9832	266.7769
41694.93519200	1.32739335	.1806672	32.9101	148.1529*	320.7690	224.1857
41701.91854290	1.32739183	.1803849	32.9153	182.9922	297.5507	175.7595
41708.99155230	1.32738810	.1803552	32.9166	218.4067	274.0333	127.2461
~~41715.97670260~~	1.32738499	.1800330	32.9195X	253.3877	250.7987	86.1156
41722.96382070	1.32738456	.1801365	32.9167	288.4540	227.5659	52.8310
41729.95236480	1.32738192	.1802263	32.9144	323.4075	204.3231	25.5085
41736.94161900	1.32737945	.1804708	32.9107	358.3465	181.0702	1.1286
41743.93089150	1.32737737	.1806460	32.9068	33.2418	157.8262	336.9321
41750.91951370	1.32737791	.1809262	32.9025	68.0743	134.5721	310.1715
41757.99631460	1.32737801	.1809311	32.9018	103.4063	111.0238	277.3467
41764.98157800	1.32737717	.1808455	32.9044	138.2056	87.7937	237.1399
~~41771.96505630~~	1.32737383	.1807390	32.9122	173.0936	64.5658	189.7863
41778.94818000	1.32737110	.1801662	32.9180	207.9626	41.3417	141.0477
41785.93262730	1.32737178	.1799780	32.9210	242.9548	18.1199	97.5287
41792.91907460	1.32737172	.1800018	32.9211	277.9318	354.8936	62.0835
41799.99677150	1.32737153	.1801555	32.9201	313.3694	331.3551	32.9304
41806.98581300	1.32737108	.1803110	32.9164	348.3131	308.0982	7.9955
41813.97510530	1.32737216	.1807907	32.9108	23.2206	284.8495	344.0316
41820.96394710	1.32737286	.1809909	32.9063	58.0867	261.6068	318.2921
~~41827.95161010~~	1.32737284	.1810065	32.9049	92.9413	238.3625	287.8436
41834.93743540	1.32737220	.1809084	32.9052	127.8095	215.1231	250.0179
41841.92133020	1.32737132	.1806566	32.9068	162.6046	191.8911	204.5064
41848.99390020	1.32737238	.1800839	32.9096	197.9001	168.3833	154.8192
41855.97783100	1.32737257	.1799878	32.9130	232.8461	145.1538	109.2932
41862.96369300	1.32737219	.1800318	32.9147	267.7891	121.9254	71.5618
41869.95138760	1.32737197	.1800476	32.9150	302.8201	98.6872	41.0695
41876.94025200	1.32737348	.1805690	32.9119X	337.8816	75.4176	15.2064
~~41883.92954930~~	1.32737357	.1800646	32.9094	12.8109	52.1780	351.2392
41890.91859120	1.32737161	.1807890	32.9050	47.6776	28.9453	326.3240
41897.99625280	1.32737003	.1808302	32.9043	82.9539	5.4036	297.2021
41904.98265120	1.32737134	.1807386	32.9063	117.7625	342.1583	261.7467
41911.96705410	1.32737279	.1805164	32.9093	152.6158	318.9379	218.1967
41918.95016070	1.32737338	.1802331	32.9137	187.4992	295.7170	169.3863
41925.93362570	1.32736374	.1799439	32.9161	222.4346	272.5046	122.1330
41932.91883320	1.32736363	.1798088	32.9159	257.4205	249.2717	81.9304
~~41939.99553920~~	1.32735799	.1797928	32.9158	292.8597	225.7549	49.1581
41946.98401880	1.32735715	.1799780	32.9131	327.8564	202.5137	22.3139
41953.97308320	1.32734708	.1802452	32.9089	2.7768	179.2629	358.1039
41960.96203900	1.32734086	.1804373	32.9046	37.6899	156.0121	333.7058
41967.95021290	1.32733763	.1805685	32.9001	72.5474	132.7680	306.3572
41974.93689450	1.32733531	.1805831	32.9001	107.3692	109.5308	273.1466
41981.92156230	1.32732827	.1804119	32.9031	142.1843	86.2936	231.9950
41988.99402970	1.32731715	.1801756	32.9120	177.5188	62.7795	183.5153

Measurement Residuals (rms)

A (e.r.)	E	INCL (DEG'S.)	OMEGA (DEG'S.)	NODE (DEG'S.)	MEAN ANOM. (DEG'S.)
0.5470D-05	0.1230D-03	0.7940D-03	0.3170D-01	0.1260D-01	0.6330D-00

Table 1f
Observations – ARC 6
(Vanguard 3 Rocket From Routine NAVSPASUR Tracking)

TIME (MJD)	A (e.r.)	E	INCL (DEG'S.)	OMEGA (DEG'S.)	NODE (DEG'S.)	MEAN ANOM. (DEG'S.)
39076.92148980	1.33197122	.1878057	33.3526	326.4241	50.1436	22.9515
39083.94732990	1.33196877	.1882196	33.3498	0.9074	27.0386	359.3969
39090.97313310	1.33196802	.1882805	33.3453	35.3431	3.9326	335.8292
39097.99823130	1.33196412	.1887395	33.3406	69.5888	340.8091	309.6602
39104.93185360	1.33196286	.1888035	33.3402	103.4391	317.9850	278.2396
39111.95353550	1.33196301	.1886223	33.3425	137.7634	294.9079	238.4407
39118.97342230	1.33196404	.1880991	33.3460	172.0290	271.8179	191.4470
~~39132.92358640~~	1.33196100	.1878280	33.3463	240.5356	225.9414	99.3914
39139.94635570	1.33195839	.1876623	33.3480	275.0045	202.8410	63.9211
39146.97083070	1.33195798	.1878996	33.3466	309.4734	179.7221	35.3210
39153.99632370	1.33195715	.1879542	33.3437	343.9362	156.6135	10.8282
39160.93206550	1.33195736	.1882537	33.3415	17.9443	133.8051	347.9111
39167.95753920	1.33195831	.1884999	33.3383	52.3466	110.6909	323.3534
39178.94370740	1.33195509	.1888415	33.3399	105.8761	74.5309	275.6989
39181.91457110	1.33195560	.1887416	33.3399	120.5428	64.7798	259.4714
~~39188.93518510~~	1.33195536	.1884661	33.3406	154.8517	41.6698	215.6703
39191.99495390	1.33195641	.1886657	33.3449	169.8997	31.6127	194.5073
39194.96466400	1.33195705	.1880581	33.3470	184.3471	21.8430	173.7504
39209.99618180	1.33195637	.1877965	33.3516	258.0659	332.4152	80.3334
39215.93919150	1.33195559	.1877868	33.3516	287.1861	312.8717	53.1558
39223.95486590	1.33195393	.1879895	33.3466	326.6099	286.4943	22.8107
39229.98974830	1.33195194	.1881124	33.3423	356.2255	266.6460	2.5375
39236.92540110	1.33195208	.1883524	33.3386	30.1939	243.8506	339.4660
~~39243.95054810~~	1.33195295	.1888383	33.3352	64.4993	220.7133	313.8489
39251.96475510	1.33195072	.1888048	33.3339	103.6560	194.3476	278.0149
39257.99622050	1.33194923	.1887254	33.3343	133.1690	174.5058	244.2617
39264.92613770	1.33194483	.1885947	33.3377	167.1009	151.6995	198.4973
39272.93530150	1.33194451	.1892485	33.3429	206.3528	125.3329	142.6884
39279.95591310	1.33194527	.1880315	33.3464	240.7537	102.2517	99.1174
39285.98808660	1.33194496	.1878132	33.3489	270.3563	82.4095	68.2308
39292.92220200	1.33194463	.1877047	33.3483	304.3375	59.6163	39.2641
~~39294.99368120~~	1.33194464	.1878529	33.3478	314.5583	52.7904	31.5247

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Table 1f (Continued)

TIME (MJD)	A (e.r.)	E	INCL (DEG'S.)	OMEGA (DEG'S.)	NODE (DEG'S.)	MEAN ANOM. (DEG'S.)
39299.94749470	1.33194302	.1880336	33.3457	338.9036	36.4937	14.2591
39306.97317210	1.33194024	.1879414	33.3432	13.3714	13.3943	351.0076
39315.97996030	1.33193731	.1885003	33.3388	57.4477	343.7464	319.4225
39321.92347690	1.33193682	.1885992	32.3371	86.5056	324.2008	294.7989
39327.95576180	1.33193487	.1885799	33.3372	115.8447	304.3533	264.8168
39334.97645970	1.33193069	.1884170	33.3393	150.2134	281.2589	222.0049
39341.99565580	1.33192283	.1881486	33.3418	184.6106	258.1653	173.3706
39348.92505530	1.33191824	.1881853	33.3463	218.5343	235.3860	126.3841
39355.94617670	1.33191581	.1876311	33.3476	253.0807	212.2789	85.5516
39362.96929070	1.33191529	.1876735	33.3475	287.5186	189.1883	52.8847
39369.99385030	1.33190961	.1876505	33.3444	321.9528	166.0815	26.1490
39376.92905460	1.33190159	.1878812	33.3413	356.0041	143.2621	2.6877
39383.95435450	1.33189725	.1880017	33.3365	30.4319	120.1549	339.2833
39385.93576760	1.33189482	.1881931	33.3358	40.1173	113.6384	332.3997
39386.92644900	1.33189357	.1882706	33.3354	44.9515	110.3773	328.8747
39390.97900830	1.33188660	.1884821	33.3347	64.7422	97.0341	313.6197
39397.91222710	1.33187757	.1884741	33.3353	98.6464	74.2219	283.0866
39404.93349760	1.33187125	.1883502	33.3376	133.0048	51.1159	244.4287
39411.95279360	1.33186345	.1881710	33.3424	167.3800	28.0301	198.0857
39418.97132590	1.33184646	.1877909	33.3473	201.7487	4.9422	149.0772
39425.99085800	1.33183184	.1876363	33.3521	236.1512	341.8635	104.5260
39432.92227960	1.33181875	.1874853	33.3540	270.1749	319.0703	68.4396
39439.94540790	1.33180441	.1874769	33.3519	304.6987	295.9660	39.0027
39446.96951820	1.33178638	.1876050	33.3483	339.1728	272.8608	14.0882
39447.96013460	1.33178339	.1876276	33.3479	344.0401	269.5992	10.7657
39449.94137490	1.33177814	.1876891	33.3459	353.7467	263.0831	4.2063
39451.92261450	1.33177314	.1877744	33.3442	3.4659	256.5637	357.6786
39453.99389640	1.33176855	.1879468	33.3425	13.6166	249.7456	350.8418
39459.93733110	1.33175716	.1881942	33.3367	42.7161	230.1887	330.5103
39460.92784830	1.33175521	.1882468	33.3360	47.5592	226.9258	326.9403
39467.95079170	1.33174223	.1883789	33.3309	81.9127	203.8037	298.9631
39474.97195470	1.33172417	.1883469	33.3301	116.1755	180.6864	264.4174
39486.93916090	1.33169794	.1879130	33.3382	174.7568	141.3031	187.5333
39489.99793300	1.33169208	.1877799	33.3413	189.7478	131.2365	166.0188
39496.92567440	1.33167200	.1875620	33.3458	223.7794	108.4292	119.6977
39503.94503780	1.33164398	.1874681	33.3486	258.2560	85.3380	80.1772
39510.96619960	1.33162586	.1875096	33.3494	292.7756	62.2334	48.5070
39517.93858040	1.33160177	.1877988	33.3479	327.3134	39.1143	22.3228
39524.92131810	1.33156628	.1879401	33.3445	1.3043	16.2897	359.1303
39531.94378540	1.33152790	.1881765	33.3429	35.7174	353.1742	335.5572
39538.96530610	1.33150282	.1885932	33.3389	69.9629	330.0448	309.3341
39545.98520460	1.33148391	.1864574	33.3369	104.4078	306.9371	277.1921
39552.91298680	1.33145871	.1883103	33.3375	138.2531	284.1311	237.7836
39555.97130780	1.33144254	.1882559	33.3381	153.2605	274.0555	217.8425
39559.92858690	1.33142229	.1879726	33.3392	172.6219	261.0203	190.5953
39560.91798370	1.33141755	.1878051	33.3381	177.4587	257.7463	183.6522
39573.95987370	1.33135902	.1873413	33.3465	241.5737	214.7937	98.2566
39580.97781650	1.33132691	.1874230	33.3510	276.0743	191.6842	62.9692
39587.99723680	1.33130323	.1876561	33.3487	310.5949	168.5527	34.4932
39594.92749940	1.33128792	.1876833	33.3465	344.6126	145.7356	10.3753
39601.94795260	1.33127496	.1879484	33.3410	19.0500	122.6044	347.1486
39604.91803640	1.33126725	.1881372	33.3372	33.5874	112.8082	337.0676
39606.98801710	1.33126147	.1883650	33.3363	43.6974	105.9778	329.8028
39608.96791320	1.33125706	.1883454	33.3356	53.4121	99.4553	322.5284
39615.98665520	1.33123931	.1883727	33.3333	87.7931	76.3378	293.5771
39621.92413060	1.33122823	.1883506	33.3367	116.8467	56.7825	263.6599
39622.91355980	1.33122764	.1883353	33.3367	121.6877	53.5195	258.0941
39624.98222970	1.33122536	.1881873	33.3384	131.7382	46.6959	245.9865
39629.92831730	1.33121593	.1880186	33.3421	155.9720	30.3892	214.0964
39635.95267710	1.33119991	.1878497	33.3477	185.5379	10.5316	172.0441
39636.94173100	1.33119644	.1877775	33.3481	190.3932	7.2802	165.0979
39643.95554950	1.33117485	.1873753	33.3535	224.8547	344.1761	118.3561
39650.97113570	1.33116750	.1873049	33.3561	259.3433	321.0645	79.0864
39657.98864590	1.33116531	.1874349	33.3538	293.8508	297.9531	47.6315
39664.91749040	1.33116233	.1875665	33.3512	327.9225	275.1234	21.9044
39671.93691750	1.33115743	.1878403	33.3444	2.4099	251.9866	358.3879
39675.98659470	1.33115553	.1879530	33.3405	22.2874	238.6464	344.9314
39678.95627310	1.33115479	.1881306	33.3386	36.8361	228.8611	334.7563
39682.91562620	1.33115380	.1882664	33.3362	56.2250	215.8113	320.3550
39685.97488150	1.33115303	.1883163	33.3340	71.2077	205.7269	308.2636
39692.99200870	1.33114828	.1883181	33.3318	105.5432	182.6056	275.9874
39699.91715010	1.33114013	.1881971	33.3358	139.4399	159.7704	236.2459
39700.99621010	1.33113832	.1881936	33.3418	144.7373	156.2368	229.3211
39706.93038250	1.33112912	.1880084	33.3438	173.8325	136.6586	188.8608
39713.94321200	1.33112138	.1878302	33.3500	208.2667	113.5483	140.1017
39720.95739910	1.33111633	.1874830	33.3539	242.7240	90.4369	96.9308
39727.97359440	1.33111113	.1873427	33.3561	277.2178	67.3159	61.9402
39734.99143520	1.33110532	.1874441	33.3533	311.7667	44.1889	33.6293
39741.92020920	1.33110034	.1876191	33.3521	345.8122	21.3637	9.5627
39748.93921270	1.33109622	.1879373	33.3487	20.2739	358.2303	346.3117
39755.95779130	1.33109122	.1882672	33.3442	54.6570	335.1005	321.5668
39762.97520090	1.33108302	.1882855	33.3414	89.0592	311.9768	292.3807
39769.99074690	1.33107278	.1882284	33.3412	123.3354	288.8420	256.1495
39776.91426820	1.33106115	.1881124	33.3436	157.2999	266.0187	212.2631
39783.92647900	1.33105121	.1878822	33.3507	191.6835	242.9081	163.2559
39790.93924830	1.33104178	.1876491	33.3554	226.1304	219.7947	116.7256
39797.95383990	1.33103135	.1874953	33.3562	260.6197	196.6739	77.7720
39804.97031290	1.33102480	.1874528	33.3550	295.1396	173.5516	46.5788
39811.98806900	1.33102025	.1876300	33.3510	329.6591	150.4223	20.6801
39818.91639830	1.33101383	.1878393	33.3468	3.6939	127.5874	357.5257
39825.93457910	1.33100573	.1882144	33.3429	38.1056	104.4422	333.8511
39832.95196070	1.33100175	.1884105	33.3412	72.4548	81.2984	307.2196
39839.96781310	1.33099535	.1883637	33.3435	106.8317	58.1632	274.6333
39846.98158070	1.33098176	.1882151	33.3464	141.1489	35.0448	234.0327
39853.99349580	1.33096924	.1880705	33.3526	175.5552	11.9232	186.3890
39860.91517390	1.33095559	.1878761	33.3596	209.5084	349.1193	138.4122
39867.92808480	1.33094041	.1875291	33.3623	243.9802	325.9973	95.5063
39874.94291670	1.33092306	.1872938	33.3629	278.5018	302.8779	60.7891
39881.95929730	1.33091096	.1873808	33.3600	313.0560	279.7498	32.6713
39888.97647620	1.33088897	.1874068	33.3546	347.5244	256.6244	8.4070

Table 1f (Continued)

TIME (MJD)	A (e.r.)	E	INCL (DEG'S.)	OMEGA (DEG'S.)	NODE (DEG'S.)	MEAN ANOM. (DEG'S.)
39895.99370380	1.33086341	.1876723	33.3475	21.9963	233.4951	345.1221
~~39902.92040230~~	1.33084952	.1879841	33.3411	55.9458	210.6437	320.5488
39909.93584330	1.33083851	.1881350	33.3389	90.2876	187.5044	291.2030
39916.94934220	1.33081943	.1880802	33.3417	124.6672	164.3603	254.5569
39916.94934240	1.33081885	.1880929	33.3425	124.6585	164.3597	254.5685
39917.93824260	1.33081452	.1880488	33.3437	129.4919	161.0968	248.7368
39923.96064070	1.33079440	.1878351	33.3475	159.0083	141.2206	209.8704
39930.97072580	1.33078074	.1876021	33.3533	193.4252	118.1215	160.7892
39937.98142110	1.33076523	.1871438	33.3591	227.8650	94.9956	114.6150
~~39944.99387960~~	1.33074259	.1871222	33.3604	262.2926	71.8875	76.1380
39951.91813620	1.33071427	.1868776	33.3597	296.4690	49.0494	45.5541
39958.93339420	1.33069332	.1870895	33.3605	330.9928	25.9142	19.7700
39962.98088460	1.33067828	.1872450	33.3567	350.8607	12.5768	6.1554
39965.94905010	1.33066974	.1871187	33.3556	5.4680	2.7952	356.3276
39972.96443370	1.33064864	.1875211	33.3502	39.8775	339.6511	332.5334
39979.97885060	1.33062601	.1877074	33.3457	74.2872	316.5227	305.5867
39986.99157210	1.33060078	.1877006	33.3459	108.5463	293.3694	272.7280
~~39993.91221130~~	1.33058111	.1876207	33.3478	142.5532	270.5538	232.1471
40000.92089200	1.33055796	.1873215	33.3512	176.9263	247.4213	184.4132

Measurement Residuals (rms)

A (e.r.)	E	INCL (DEG'S.)	OMEGA (DEG'S.)	NODE (DEG'S.)	MEAN ANOM. (DEG'S.)
0.9930D-05	0.1460D-03	0.1380D-02	0.4690D-01	0.2370D-01	0.1760D+01

Table 1g
Observations – ARC 7
(Vanguard 3 Rocket From Routine NAVSPASUR Tracking)

TIME (MJD)	A (e.r.)	E	INCL (DEG'S.)	OMEGA (DEG'S.)	NODE (DEG'S.)	MEAN ANOM. (DEG'S.)
40007.92922960	1.33053594	.1870884	33.3539	211.3911	224.3103	135.9312
40014.93892010	1.33051948	.1868869	33.3545	245.8857	201.1942	93.4498
40021.95051920	1.33050054	.1868080	33.3530	280.4229	178.0612	59.1274
40028.96359890	1.33048471	.1870162	33.3507	314.9859	154.9103	31.2644
40035.97744220	1.33046754	.1871204	33.3479	349.4672	131.7737	7.0982
40037.95574840	1.33046220	.1872067	33.3465	359.1824	125.2499	0.5548
40042.99136160	1.33045043	.1874436	33.3438	23.9226	108.6231	343.7874
40049.91479800	1.33043846	.1877039	33.3412	57.8796	85.7659	319.0194
40056.92685070	1.33041991	.1877054	33.3417	92.3151	62.6294	2[illegible]9.2172
40063.93693240	1.33040228	.1876116	33.3430	126.6271	39.4959	252.1632
40070.94487030	1.33038349	.1873654	33.3490	161.0030	16.3669	207.0581
40076.96353580	1.33036704	.1871395	33.3541	190.5969	356.5019	164.8254
40077.95157540	1.33036329	.1870216	33.3545	195.4537	353.2366	157.9403
40084.95913010	1.33033948	.1868471	33.3580	229.9439	330.1209	112.0832
40091.96834750	1.33031835	.1868340	33.3595	264.4610	306.9956	74.0246
40098.97932490	1.33030470	.1869147	33.3569	298.9936	283.8515	43.5261
40105.99141760	1.33028609	.1871522	33.3527	333.5199	260.6990	18.0052
~~40107.96927960~~	1.33027850	.1872389	33.3514	343.2476	254.1671	11.3145
40109.94715010	1.33026988	.1873457	33.3501	352.9779	247.6328	4.7271
40111.92501090	1.33026167	.1873489	33.3492	2.6993	241.0995	358.1914
40112.91393410	1.33025745	.1873326	33.3484	7.5634	237.8358	354.9188
40112.91393430	1.33025729	.1873514	33.3483	7.5591	237.8363	354.9219
40115.97055000	1.33024287	.1874834	33.3474	22.5864	227.7388	344.7098
40119.92597730	1.33022735	.1876216	33.3446	42.0196	214.6831	330.9831
40126.93698420	1.33020476	.1878011	33.3412	76.4407	191.5214	303.7374
~~40133.94623750~~	1.33017726	.1878617	33.3431	110.7819	168.3816	270.3331
40140.95323970	1.33015202	.1876949	33.3453	145.1732	145.2466	228.7025
40147.95841060	1.33012387	.1874996	33.3499	179.6106	122.1112	180.5590
40154.96333550	1.33008910	.1870136	33.3573	214.0407	98.9733	132.3977
40161.96953200	1.33004636	.1869332	33.3609	248.5352	75.8385	90.5251
40168.97746780	1.33001523	.1869257	33.3633	283.1007	52.6858	56.7604
40175.98677410	1.32999339	.1870934	33.3636	317.6268	29.5355	29.3181
40182.99677520	1.32997472	.1873986	33.3614	352.1343	6.3810	5.2946
~~40189.91691450~~	1.32995838	.1874616	33.3580	26.1468	343.5212	342.2490
40196.92629120	1.32994162	.1876288	33.3551	60.5735	320.3650	316.8891
40203.93432630	1.32992947	.1877243	33.3537	94.9502	297.2134	286.6624
40210.94038690	1.32991906	.1876584	33.3544	129.3598	274.0731	248.8569
40217.94437130	1.32990162	.1874522	33.3575	163.7449	250.9259	203.2080
40224.94736680	1.32988448	.1871861	33.3602	198.1895	227.7859	154.0823
40231.95120650	1.32987173	.1868891	33.3632	232.6716	204.6513	108.7627
40238.95693350	1.32985907	.1866904	33.3648	267.2221	181.4998	71.3517
~~40245.96442000~~	1.32985042	.1868373	33.3645	301.7668	158.3466	41.3395
40252.97301300	1.32984097	.1870219	33.3634	336.2666	135.1983	16.1074
40259.98198590	1.32982694	.1872860	33.3609	10.7409	112.0328	352.7742
40266.99055520	1.32981555	.1874854	33.3581	45.1814	88.8660	328.6530
40273.99834460	1.32980637	.1875889	33.3588	79.5711	65.7126	300.9683
40280.91451350	1.32979112	.1875332	33.3626	113.4830	42.8654	267.3307
40287.91832890	1.32977432	.1873677	33.3646	147.9278	19.7148	225.0054
40294.92050590	1.32975818	.1871531	33.3695	182.3533	356.5753	176.6214
~~40301.92267390~~	1.32973521	.1868652	33.3748	216.7932	333.4439	128.7768

Table 1g (Continued)

TIME (MJD)	A (e.r.)	E	INCL (DEG'S.)	OMEGA (DEG'S.)	NODE (DEG'S.)	MEAN ANOM. (DEG'S.)
40308.92631420	1.32971131	.1866450	33.3751	251.3281	310.2984	87.5359
40315.93184490	1.32969908	.1866616	33.3733	285.8633	287.1534	54.3980
40322.93879300	1.32968948	.1868228	33.3703	320.3933	263.9961	27.3219
40329.94644710	1.32967937	.1869690	33.3663	354.8783	240.8286	3.4509
40336.95414040	1.32967048	.1874653	33.3615	29.3223	217.6592	340.0364
40343.96119250	1.32966310	.1875928	33.3589	63.7348	194.5020	314.3548
40350.96689410	1.32965688	.1875970	33.3567	98.1267	171.3446	283.5051
40357.97060410	1.32964541	.1874428	33.3574	132.5150	148.1891	244.9462
40364.97231800	1.32963684	.1871842	33.3617	166.9099	125.0396	198.7197
40371.97329850	1.32963279	.1868164	33.3659	201.3521	101.8937	149.6831
40378.97534660	1.32963067	.1867514	33.3702	235.8521	78.7574	104.9774
40385.97938160	1.32962469	.1867067	33.3725	270.4073	55.6118	68.3072
40392.98515350	1.32961741	.1867983	33.3731	304.9387	32.4557	38.8941
40399.99202000	1.32961680	.1869953	33.3698	339.4288	9.2926	13.9317
40406.99927970	1.32961511	.1873060	33.3652	13.9107	346.1235	350.6291
40413.91641290	1.32961064	.1873784	33.3600	47.9465	323.2534	326.5906
40420.92238510	1.32960459	.1875126	33.3577	82.3017	300.0967	298.5199
40427.92666810	1.32960370	.1874824	33.3583	116.6578	276.9360	263.7624
40434.92888030	1.32960162	.1873304	33.3598	151.1166	253.7924	220.7017
40441.92968010	1.32959625	.1868355	33.3619	185.4926	230.6390	172.1239
40448.93072180	1.32959189	.1867864	33.3647	220.0096	207.4991	124.5968
40455.93352110	1.32959143	.1866079	33.3668	254.5329	184.3540	84.1393
40462.93830000	1.32958703	.1865610	33.3658	289.1392	161.1898	51.6245
40469.94444440	1.32957503	.1866912	33.3636	323.6269	138.0396	25.0012
40476.95122500	1.32956378	.1868049	33.3608	358.1468	114.8772	1.2521
40483.95796370	1.32955268	.1870582	33.3565	32.6421	91.7079	337.6826
40490.96395750	1.32953770	.1873212	33.3553	67.0605	68.5279	311.6192
40497.96845050	1.32951778	.1873593	33.3570	101.4208	45.3677	280.1471
40504.97084820	1.32950271	.1872307	33.3616	135.8204	22.2199	240.7791
40511.97126890	1.32948630	.1869649	33.3671	170.2294	359.0790	193.9914
40518.97103070	1.32946660	.1867827	33.3741	204.6966	335.9411	145.0582
40525.97184180	1.32943569	.1863386	33.3777	239.1965	312.7992	101.1064
40532.97448030	1.32941340	.1861497	33.3776	273.7739	289.6478	65.2208
40539.97867220	1.32939068	.1863659	33.3750	308.3763	266.4847	36.2670
40546.98371460	1.32936685	.1864814	33.3711	342.8547	243.3211	11.6018
40553.98885910	1.32933251	.1866654	33.3650	17.3275	220.1586	348.2891
40560.99341440	1.32930414	.1868333	33.3582	51.8103	196.9898	323.6355
40567.99675150	1.32928521	.1870007	33.3532	86.1737	173.8196	294.9292
40574.99821730	1.32926682	.1869743	33.3545	120.5485	150.6599	259.2648
40581.99745460	1.32923843	.1868270	33.3580	154.9874	127.5024	215.3795
40588.99523170	1.32921338	.1866491	33.3635	189.4576	104.3543	166.4622
40595.99334450	1.32919360	.1864610	33.3684	223.9309	81.2060	119.6129
40602.99312850	1.32916510	.1861701	33.3713	258.4610	58.0494	80.1190
40609.99455850	1.32911861	.1859917	33.3715	293.0144	34.8930	48.4522
40616.99704470	1.32908511	.1861674	33.3675	327.5933	11.7299	22.2045
40623.99990710	1.32905318	.1864017	33.3663	2.1473	348.5525	358.5593
40630.91267500	1.32901320	.1865086	33.3626	36.2419	325.6761	335.0933
40637.91411890	1.32895751	.1857066	33.3575	70.7021	302.5007	308.5321
40644.91372850	1.32891007	.1868382	33.3550	105.0610	279.3261	276.3198
40651.91096320	1.32886303	.1867090	33.3556	139.5057	256.1548	236.0235
40658.99572600	1.32881273	.1864451	33.3581	174.3576	232.6915	188.0837
40665.99013740	1.32877117	.1862210	33.3607	208.8554	209.5258	139.4161
40672.98561900	1.32872695	.1860720	33.3636	243.4093	186.3597	96.3174
40679.98276080	1.32867985	.1861295	33.3633	277.9627	163.1826	61.3986
40686.98119490	1.32862880	.1862340	33.3609	312.5695	139.9907	33.1136
40693.98016530	1.32858020	.1862227	33.3576	347.0970	116.8080	8.7197
40700.97903520	1.32853670	.1864779	33.3536	21.6420	93.6074	345.3263
40707.97719240	1.32850239	.1867887	33.3516	56.1019	70.4034	320.3312
40714.97391800	1.32846501	.1868666	33.3524	90.5471	47.2100	290.8132
40721.96859840	1.32843885	.1867539	33.3546	124.9948	24.0483	254.0215
40728.96105670	1.32841329	.1866047	33.3562	159.4646	0.8612	209.1683
40735.95228590	1.32839043	.1862855	33.3603	193.9355	337.6833	160.1141
40742.94406820	1.32836882	.1861255	33.3641	228.4638	314.5140	113.9789
40749.93765760	1.32835713	.1860028	33.3660	263.0618	291.3299	75.5026
40756.93303160	1.32834094	.1860929	33.3646	297.6646	268.1401	44.6611
40763.92954490	1.32832746	.1861501	33.3604	332.1900	244.9553	18.9730
40770.92651260	1.32831410	.1864853	33.3529	6.7683	221.7479	355.4457
40777.92322730	1.32829794	.1866049	33.3486	41.3150	198.5452	331.4343
40784.91901090	1.32828557	.1867414	33.3466	75.7946	175.3498	304.1895
40791.91317010	1.32827637	.1867755	33.3474	110.2815	152.1506	270.7495
40796.93330900	1.32826624	.1867537	33.3509	135.0249	135.5050	241.7366

Measurement Residuals (rms)

A (e.r.)	E	INCL (DEG'S.)	OMEGA (DEG'S.)	NODE (DEG'S.)	MEAN ANOM. (DEG'S.)
0.1270D-04	0.1390D-03	0.1270D-02	0.3030D-01	0.2110D-01	0.1310D+01

Table 1h
Observations – ARC 8
(Vanguard 3 Rocket From Routine NAVSPASUR Tracking)

TIME (MJD)	A (e.r.)	E	INCL (DEG'S.)	OMEGA (DEG'S.)	NODE (DEG'S.)	MEAN ANOM. (DEG'S.)
40805.98517450	1.32825518	.1863158	33.3575	179.6030	105.4935	180.5684
40819.96727980	1.32824739	.1859515	33.3635	248.6825	59.1255	90.4788
40826.96110060	1.32824235	.1858941	33.3646	283.2618	35.9386	56.7262
40833.95643020	1.32823391	.1860098	33.3642	317.8901	12.7469	29.1933
40840.95252060	1.32822429	.1860563	33.3632	352.4223	349.5600	5.1163
40847.94869760	1.32821607	.1863993	33.3587	26.9530	326.3486	341.6457
40854.94428400	1.32820793	.1866007	33.3541	61.4458	303.1451	316.1055
40861.93856680	1.32820057	.1866854	33.3517	95.8742	279.9417	285.6352
40868.93091400	1.32819522	.1865394	33.3516	130.2882	256.7534	247.6030
40875.92126390	1.32818711	.1863305	33.3552	164.7815	233.5753	201.6993
40882.91069860	1.32816947	.1862200	33.3595	199.3439	210.4007	152.5134
40889.99066190	1.32815542	.1859961	33.3632	234.3439	186.9258	106.8527
40896.98288010	1.32813916	.1859072	33.3620	268.9051	163.7393	69.8247
40903.97680230	1.32812582	.1859809	33.3603	303.5199	140.5407	40.0382
40910.97178410	1.32811653	.1862001	33.3576	338.1267	117.3400	14.8526
40917.96710740	1.32810487	.1864354	33.3550	12.6771	94.1295	351.4483
40924.96211780	1.32809790	.1865600	33.3534	47.1872	70.9200	327.1007
40931.95611290	1.32808694	.1866072	33.3559	81.6937	47.7334	298.9699
40938.94838930	1.32807733	.1866338	33.3574	116.0505	24.5324	264.3607
40945.93855820	1.32807221	.1864610	33.3601	150.5213	1.3373	221.4454
40952.92730120	1.32807268	.1861442	33.3634	185.0020	338.1537	172.8360
40966.99665250	1.32806543	.1858064	33.3673	254.5846	291.4993	84.1788
40973.98933860	1.32805821	.1857460	33.3656	289.2158	268.3042	51.6393
40980.98341380	1.32805226	.1860098	33.3608	323.8164	245.0998	24.9021
40987.97815710	1.32804657	.1862415	33.3554	358.3871	221.8912	1.0917
~~40994.97290410~~	1.32804377	.1864526	33.3506	32.9206	198.6792	337.4557
41001.96697780	1.32803970	.1865816	33.3476	67.3978	175.4738	311.2721
41008.95964300	1.32803333	.1866140	33.3473	101.8200	152.2670	279.6514
41015.95028340	1.32802415	.1865185	33.3511	136.2826	129.0797	240.1246
41022.93902740	1.32801715	.1862649	33.3557	170.7714	105.8854	193.2011
41029.92724420	1.32801245	.1859279	33.3599	205.2860	82.7016	144.3027
41036.91669240	1.32801065	.1857810	33.3633	239.8607	59.5216	100.4011
41043.99779400	1.32800780	.1857280	33.3659	274.8745	36.0348	64.2522
41050.99095940	1.32800147	.1857641	33.3648	309.5111	12.8315	35.4495
41057.98507370	1.32799117	.1858739	33.3619	344.0886	349.6361	10.7750
41064.97941560	1.32798153	.1860617	33.3575	18.5537	326.4222	347.3656
41071.97334540	1.32797607	.1863331	33.3518	53.1299	303.2161	322.5893
41078.96615670	1.32796921	.1863441	33.3483	87.6014	280.0158	293.5301
41085.95712700	1.32795583	.1862537	33.3485	122.0597	256.8177	257.4264
41092.94595680	1.32793844	.1860483	33.3519	156.5175	233.6295	213.2237
41099.93351540	1.32792868	.1856537	33.3571	191.0156	210.4495	164.2735
~~41106.92160100~~	1.32792296	.1855063	33.3588	225.6116	187.2706	117.5901
41113.91151190	1.32791764	.1854250	33.3590	260.2502	164.0779	78.3849
41120.99297650	1.32791451	.1855680	33.3596	295.3139	140.5874	46.6054
41127.98608370	1.32790954	.1856384	33.3575	329.8767	117.3862	20.6134
41134.97973470	1.32790039	.1858509	33.3563	4.4590	94.1801	356.9928
41141.97323840	1.32789280	.1861788	33.3534	38.9551	70.9702	333.1163
41148.96592230	1.32788733	.1861998	33.3511	73.4562	47.7654	306.1414
41155.95706820	1.32787986	.1862064	33.3510	107.8695	24.5603	273.2726
~~41162.94612340~~	1.32786927	.1861038	33.3543	142.3802	1.3726	232.2387
41169.93341740	1.32785577	.1858282	33.3603	176.8338	338.1970	184.5334
41176.92043160	1.32784349	.1856983	33.3650	211.3997	315.0112	136.0265
41183.99848950	1.32783589	.1853248	33.3654	246.4449	291.5328	93.0096
41197.98087970	1.32782068	.1855191	33.3610	315.6566	245.1354	30.8636
41204.97366670	1.32781082	.1857689	33.3574	350.2641	221.9306	6.5752
41211.96655380	1.32779798	.1860612	33.3546	24.8087	198.7182	343.1178
41218.95884560	1.32778288	.1861902	33.3501	59.3621	175.5142	317.7201
41225.94983170	1.32776852	.1863772	33.3471	93.7230	152.2835	287.6995
41232.93886750	1.32775816	.1862540	33.3477	128.2028	129.0950	250.1129
41239.92584910	1.32774590	.1859910	33.3536	162.6716	105.8928	204.6536
41246.91182230	1.32773163	.1858813	33.3622	197.2018	82.7199	155.5295
41253.98817640	1.32771758	.1855396	33.3677	232.2308	59.2227	109.4392
41260.97682800	1.32770552	.1855456	33.3707	266.8192	36.0275	71.8700
41267.96722640	1.32769150	.1855704	33.3709	301.4311	12.8291	41.7062
41274.95870010	1.32767776	.1858292	33.3677	336.0252	349.6213	16.3130
41281.95052880	1.32766161	.1861017	33.3642	10.6025	326.4021	352.8433
41288.94203860	1.32764861	.1862714	33.3585	45.1137	303.1866	328.6164
41295.93256670	1.32763970	.1863439	33.3544	79.6167	279.9798	300.7913
41302.92141010	1.32763051	.1863811	33.3531	114.0821	256.7661	266.5289
41309.99769550	1.32761879	.1861625	33.3547	148.9597	233.2625	223.5268
41316.98283590	1.32760676	.1858276	33.3582	183.4508	210.0728	175.0592
41323.96809010	1.32759979	.1855105	33.3618	218.0387	186.8727	127.2677
41330.95498410	1.32759389	.1854830	33.3647	252.6326	163.6763	86.2778
41337.94383430	1.32758692	.1855560	33.3660	287.2642	140.4709	53.3082
41344.93408570	1.32757592	.1855952	33.3657	321.8568	117.2621	26.3309
~~41351.92501760~~	1.32756596	.1858511	33.3635	356.4240	94.0553	2.4117
41358.91596490	1.32756032	.1860742	33.3590	30.9675	70.8344	338.8122
41365.99586190	1.32755250	.1861963	33.3548	65.9541	47.3171	312.4171
41372.98470690	1.32753909	.1862993	33.3551	100.4213	24.0946	281.0370
41379.97152450	1.32752762	.1861477	33.3584	134.8509	0.9010	241.8934
41386.95640130	1.32751580	.1857512	33.3634	169.2988	337.7086	195.2832
41393.94062340	1.32750737	.1855292	33.3659	203.8808	314.5097	146.2591
41400.92599080	1.32749934	.1852332	33.3664	238.4788	291.3197	102.0637
41407.91329850	1.32749170	.1852706	33.3649	273.1166	268.1001	65.9259
41414.99192580	1.32748665	.1854610	33.3653	308.1923	244.6049	36.4717
41421.98194220	1.32747898	.1855855	33.3628	342.7779	221.3908	11.6731
41428.97223470	1.32746985	.1858795	33.3569	17.3407	198.1769	348.2537
41435.96213760	1.32746419	.1861149	33.3509	51.8675	174.9584	323.5321
41442.95095040	1.32745802	.1862336	33.3482	86.3428	151.7354	294.6829
41449.93799050	1.32745403	.1861614	33.3497	120.8376	128.5285	258.8351
41456.92295320	1.32744554	.1859726	33.3547	155.2955	105.3160	214.9018
~~41463.99621330~~	1.32744464	.1854386	33.3598	190.2140	81.8265	165.4180
41470.98045930	1.32744501	.1854581	33.3652	224.8312	58.6390	118.5748
41477.96654340	1.32744083	.1853265	33.3685	259.4036	35.4452	79.2548
41484.95453800	1.32743667	.1853540	33.3687	294.0561	12.2282	47.6526
41491.94383780	1.32743262	.1855524	33.3656	328.6674	349.0106	21.4704
41498.93373050	1.32743023	.1858815	33.3619	3.2619	325.7991	357.8009
41505.92354330	1.32742606	.1861103	33.3581	37.8017	302.5849	333.9450
41512.91257890	1.32742202	.1863221	33.3542	72.2504	279.3583	307.1809
~~41519.98969690~~	1.32742089	.1862149	33.3520	107.1928	255.8481	273.9938

ORIGINAL PAGE IS
OF POOR QUALITY

Table 1h (Continued)

TIME (MJD)	A (e.r.)	E	INCL (DEG'S.)	OMEGA (DEG'S.)	NODE (DEG'S.)	MEAN ANOM. (DEG'S.)
41526.97521510	1.32742016	.1859478	33.3517	141.6296	232.6276	233.2029
41533.95902760	1.32742011	.1857677	33.3555	176.1780	209.4367	185.4714
41540.94258110	1.32741091	.1856014	33.3609	210.7607	186.2445	136.8914
41547.92758720	1.32740840	.1853078	33.3647	245.3698	163.0450	94.2059
41554.91461170	1.32740831	.1854396	33.3659	280.0428	139.8336	59.6073
41561.99281550	1.32740381	.1853462	33.3646	314.9585	116.3286	31.3916
41568.98230120	1.32739706	.1853940	33.3612	349.6261	93.1044	7.0133
41575.97195630	1.32739258	.1859087	33.3573	24.1814	69.8789	343.5470
41582.96111070	1.32739000	.1860462	33.3547	58.7236	46.6657	318.2120
41589.94905870	1.32738600	.1861683	33.3550	93.1511	23.4429	288.2302
41596.93511440	1.32738015	.1861329	33.3580	127.6507	0.2289	250.7679
41603.91916960	1.32737437	.1858144	33.3626	162.0949	337.0294	205.4542
41610.99177290	1.32736728	.1855583	33.3669	197.0766	313.5347	155.7194
41617.97568210	1.32735908	.1853097	33.3692	231.6535	290.3408	110.1622
41624.96144160	1.32734377	.1852093	33.3695	256.1780	267.1397	72.5309
41631.94899350	1.32733557	.1852974	33.3678	300.9450	243.9297	42.1129
41638.93767730	1.32733060	.1855169	33.3653	335.5385	220.7159	16.6620
41645.92677490	1.32732145	.1855129	33.3575	10.1101	197.5060	353.1679
41652.91560380	1.32731162	.1857662	33.3500	44.6529	174.2789	328.9241
41659.99307060	1.32730625	.1859091	33.3470	79.6260	150.7608	300.7370
41666.97930350	1.32730139	.1859017	33.3494	114.0103	127.5418	266.5528
41673.96342950	1.32729188	.1857277	33.3549	148.5323	104.3367	224.0673
41680.94603770	1.32728818	.1853507	33.3600	183.0341	81.1366	175.6598
41687.92877640	1.32728495	.1851703	33.3656	217.6009	57.9507	127.8681
41694.91315330	1.32727675	.1849927	33.3687	252.1971	34.7555	86.7992
41701.98904530	1.32726782	.1849625	33.3696	287.2882	11.2481	53.3467
41708.97679540	1.32725865	.1851458	33.3677	321.9538	348.0375	26.2863
41715.96521050	1.32724735	.1853394	33.3646	356.5446	324.8217	2.3329
41722.95350770	1.32723525	.1856047	33.3594	31.1011	301.6108	338.6960
41729.94130180	1.32722379	.1858624	33.3528	65.5737	278.3812	312.6976
41736.92758380	1.32721592	.1857772	33.3497	100.1012	255.1745	281.3010
41743.91188840	1.32720909	.1856473	33.3495	134.5636	231.9564	242.2048
41750.98376470	1.32719764	.1855396	33.3562	169.5168	208.4549	194.9673
41757.96544550	1.32718205	.1852737	33.3614	204.0754	185.2561	146.0068
41764.94823350	1.32717087	.1850864	33.3646	238.6746	162.0535	101.8524
41771.93297990	1.32716495	.1851281	33.3651	273.3493	138.8558	65.7253
41778.91937140	1.32715191	.1851483	33.3638	307.9139	115.6408	36.7083
41785.99628330	1.32713638	.1852924	33.3612	342.9866	92.1048	11.5379
41792.98385100	1.32712395	.1857871	33.3575	17.5503	68.8710	348.1078
41799.97100150	1.32711481	.1858303	33.3552	52.0966	45.6538	323.3356
41806.95700600	1.32709963	.1859974	33.3559	86.5697	22.4358	294.4464
41813.94116730	1.32708725	.1858614	33.3564	121.0228	359.2125	258.5867
41820.92323390	1.32707933	.1856167	33.3606	155.5080	336.0006	214.5876
41827.99352340	1.32707432	.1855938	33.3642	190.5288	312.5093	164.9666
41834.97482060	1.32705624	.1853410	33.3657	225.1244	289.2962	118.2177
41841.95792630	1.32706046	.1852284	33.3684	259.7225	266.0984	78.9422
41848.94293880	1.32705665	.1852471	33.3669	294.4055	242.8799	47.3762
41855.92923460	1.32705220	.1853615	33.3614	328.9871	219.6587	21.2536
41862.91610310	1.32704574	.1855218	33.3569	3.6068	196.4290	357.5663
41869.99242700	1.32703991	.1858282	33.3525	38.5976	172.8928	333.3545
41876.97838330	1.32703688	.1859508	33.3490	73.1248	149.6614	306.3996
41883.90283580	1.32703381	.1859862	33.3504	107.5675	126.4393	273.5686
41890.94525690	1.32702939	.1858415	33.3550	142.0304	103.2249	232.6719
41897.92594220	1.32702299	.1855533	33.3614	176.5621	80.0188	184.9200
41904.99593200	1.32702174	.1851889	33.3662	211.5835	56.5239	135.8191
41911.97790450	1.32702274	.1852176	33.3684	246.1809	33.3018	93.3146
41918.96191030	1.32702069	.1851463	33.3690	280.8014	10.0934	58.9646
41925.94749290	1.32701665	.1851558	33.3682	315.4579	346.8683	31.0344
41932.93393890	1.32701326	.1854380	33.3640	350.0821	323.6351	6.7035
41939.92054850	1.32700870	.1855628	33.3582	24.6872	300.4186	343.1835
41946.99620130	1.32700409	.1857999	33.3540	59.6477	276.8897	317.4608
41953.98105480	1.32700020	.1858897	33.3527	94.0834	253.6646	287.2930
41960.96402030	1.32699675	.1857230	33.3525	128.5425	230.4362	249.6444
41967.94501750	1.32699624	.1855258	33.3569	163.0883	207.2317	204.0480
41974.92510620	1.32699131	.1854080	33.3613	197.6684	184.0338	154.8968
41981.99560140	1.32698733	.1850743	33.3652	232.7037	160.5162	108.9185
41988.97855580	1.32698577	.1850691	33.3650	267.3714	137.3059	71.3905

Measurement Residuals (rms)

A (e.r.)	E	INCL (DEG'S.)	OMEGA (DEG'S.)	NODE (DEG'S.)	MEAN ANOM. (DEG'S.)
0.75000-05	0.83900-04	0.97100-03	0.31300-01	0.17100-01	0.83500-00

Table 11

Observations – ARC 9

(Vanguard 2 Rocket From Special NAVSPASUR Tracking)

TIME (MJD)	A (e.r.)	E	INCL (DEG'S.)	OMEGA (DEG'S.)	NODE (DEG'S.)	MEAN ANOM. (DEG'S.)
39129.96924250	1.33085902	.1821261	32.9122	341.8087	178.1908	12.4327
~~39139.95481380~~	1.33085974	.1827422	32.9064	31.3580	145.2184	338.3794
39149.93912210	1.33085934	.1830865	32.9056	80.7866	112.2703	299.4024
39159.92015730	1.33086059	.1833904	32.9120	130.2262	79.3100	247.3478
39169.98742180	1.33086237	.1826375	32.9172	180.0092	46.0707	179.9870
39179.96482120	1.33086574	.1823915	32.9243	229.4215	13.1520	113.1876
39189.94592910	1.33086974	.1822800	32.9211	279.0610	340.2010	60.8207
39199.93033730	1.33087110	.1819483	32.9165	328.6234	307.2641	21.6719
39209.91604910	1.33087296	.1822995	32.9064	18.1795	274.3006	347.5892
~~39219.99099290~~	1.33087406	.1828304	32.9015	68.1415	241.0604	310.2960
39229.97319050	1.33087263	.1829197	32.9022	117.4912	208.1072	262.3035
39239.95143730	1.33086743	.1826557	32.9090	166.8672	175.1655	198.6234
39249.92834530	1.33086109	.1821639	32.9146	216.3890	142.2251	129.7097
39259.99820140	1.33085669	.1817878	32.9176	266.3319	108.9896	72.7730
39269.98178480	1.33085429	.1816974	32.9174	315.9242	76.0523	30.9152
39279.96713700	1.33085018	.1817763	32.9153	5.6071	43.1369	356.1830
39289.95224420	1.33084829	.1825177	32.9105	55.0564	10.1676	320.7960
~~39299.93506720~~	1.33084460	.1826197	32.9069	104.4521	337.2295	276.4574
39309.91397030	1.33083845	.1822700	32.9097	153.8198	304.2793	216.6823
39319.98029140	1.33082988	.1819104	32.9154	203.7440	271.0564	146.6650
39329.95883050	1.33082257	.1817889	32.9181	253.1657	238.1434	86.1450
39339.94118260	1.33081640	.1818562	32.9136	302.7900	205.1872	40.9444
39349.92579200	1.33080650	.1816511	32.9122	352.4676	172.2374	5.1315
39359.91062110	1.33079646	.1826161	32.9092	41.8751	139.2652	330.7718
39369.98351940	1.33078211	.1827343	32.9095	91.8408	106.0534	289.1025
~~39379.96271510~~	1.33077280	.1825023	32.9100	141.1738	73.0861	233.4867
39389.93861590	1.33076421	.1823262	32.9168	190.6590	40.1467	164.8742
39[illegible]9.91545290	1.33075202	.1819734	32.9220	240.1749	7.2186	100.4692
39[illegible]9.98596470	1.33073821	.1817973	32.9220	290.2012	333.9860	51.1901
39419.96925460	1.33072037	.1822721	32.9156	339.7776	301.0352	13.8330
39429.95316640	1.33070407	.1827035	32.9093	29.3179	268.0692	339.8234
39449.91490410	1.33067539	.1826554	32.9027	128.1436	202.1123	249.8013
39459.98009500	1.33066272	.1820540	32.9101	178.0061	168.8805	182.8352
~~39469.95508460~~	1.33065091	.1816618	32.9174	227.6843	135.9377	115.3985
39479.93349360	1.33063498	.1819696	32.9227	277.2141	103.0009	62.5220
39489.91509340	1.33062294	.1821029	32.9218	326.8205	70.0279	22.9509
39529.92427840	1.33058119	.1823275	32.9122	164.9757	297.8922	201.2676
39539.98775730	1.33057001	.1819921	32.9178	214.9408	264.6637	131.6211
39549.96425830	1.33056038	.1819437	32.9169	254.5644	231.7122	74.4849
39559.94433130	1.33054676	.1820910	32.9190	314.1984	198.7477	32.1761
39569.92615370	1.33053690	.1826553	32.9103	3.6673	165.7962	357.5093
39579.99760720	1.33052200	.1827368	32.9045	53.6108	132.5048	321.9347
39589.97677050	1.33050876	.1826621	32.9043	103.0185	99.5429	277.9508
39599.95197090	1.33049914	.1824217	32.9118	152.4666	66.5798	218.5279
39609.92456600	1.33048893	.1820838	32.9207	202.0125	33.6443	149.0329
39619.98901170	1.33048257	.1819871	32.9235	251.9998	0.4187	87.3614
39629.96747530	1.33048022	.1819491	32.9223	301.6273	327.4532	41.8545
39639.94829450	1.33047170	.1825333	32.9186	351.2409	294.4935	5.9572
39649.92937700	1.33046848	.1826397	32.9107	40.7545	261.5411	331.5962
39659.99869670	1.33046958	.1828912	32.9037	90.5838	228.2512	290.3236
39669.97453540	1.33046974	.1826441	32.9062	139.9571	195.2972	235.0674
~~39679.94710900~~	1.33047068	.1820914	32.9125	189.4158	162.3392	166.6371
39689.92062300	1.33047152	.1820068	32.9175	238.9510	129.4100	101.8774
39699.98791370	1.33046979	.1817744	32.9196	289.0177	96.1462	52.1914
39709.96822940	1.33046889	.1820513	32.9161	338.6817	63.1722	14.6002
39719.94940670	1.33046839	.1824894	32.9129	28.2332	30.2103	340.5796
39729.92942500	1.33046348	.1827977	32.9093	77.6274	357.2411	302.1773
39739.99606520	1.33045378	.1827291	32.9114	127.4525	323.9731	250.6419
39749.96895030	1.33044355	.1823762	32.9162	176.8909	291.0298	184.4228
~~39759.94142250~~	1.33043244	.1818796	32.9205	226.4055	258.0903	116.9609
39769.91731830	1.33042137	.1816627	32.9223	276.0364	225.1309	63.6293
39779.98635590	1.33040669	.1814849	32.9202	326.0954	191.8819	23.5015
39789.96670140	1.33038755	.1818586	32.9117	15.7375	158.9076	349.2522
39799.94616120	1.33036287	.1824779	32.9069	65.0605	125.9219	312.8073
39809.92273310	1.33034826	.1824632	32.9086	114.5700	92.9639	265.5326
39819.98503730	1.33032615	.1820288	32.9176	164.3802	59.7200	202.0891
39829.95572190	1.33030541	.1816792	32.9248	213.9030	26.7799	133.0132
~~39839.92913360~~	1.33028400	.1814028	32.9252	263.5438	353.8378	75.5554
39849.99576300	1.33023988	.1813685	32.9226	313.6583	320.5778	32.6298
39859.97392300	1.33018818	.1814376	32.9151	3.3280	287.6031	357.7336
39859.97395180	1.33020015	.1814909	32.9136	3.3228	287.6141	357.7374
39869.95153020	1.33015323	.1820159	32.9021	52.8211	254.6548	322.4888
39879.92646930	1.33011951	.1823220	32.8999	102.2284	221.6665	278.7256
39889.98699550	1.33006916	.1816954	32.9034	151.9599	188.3834	219.1626
39899.95451900	1.33001897	.1813096	32.9113	201.5482	155.4378	149.7150
39909.92359830	1.32998212	.1813240	32.9188	251.2033	122.4647	88.2916
39919.98585730	1.32988428	.1816129	32.9159	301.3756	89.1943	42.0822
39979.98467200	1.32972504	.1814854	32.9090	239.3587	250.7085	101.4643
39989.95357340	1.32970611	.1814014	32.9084	289.0530	217.7229	52.1982
39999.92519290	1.32969005	.1817630	32.9041	338.7477	184.7188	14.5638
40009.98730030	1.32966980	.1821102	32.8972	28.7725	151.4143	340.1826
40019.95817880	1.32964867	.1823290	32.8949	78.3110	118.4153	301.5257
40029.92566920	1.32963331	.1823198	32.8982	127.7613	85.4169	250.2266
~~40039.97903810~~	1.32962320	.1820416	32.9048	177.6955	52.1457	183.2767
40059.99888970	1.32960489	.1816087	32.9123	277.5093	345.8674	62.2929
40069.96893670	1.32960070	.1815319	32.9120	327.1080	312.8832	22.7735
40079.94026580	1.32959517	.1820460	32.9029	16.6716	279.8901	348.6138
40089.91084510	1.32958684	.1822494	32.8954	66.2062	246.8743	311.8450
40099.96841360	1.32958008	.1822397	32.8967	116.1285	213.5772	263.7637
40109.93217010	1.32956945	.1818750	32.9034	165.5853	180.5894	200.3956
40119.98416460	1.32955890	.1815047	32.9083	215.6665	147.3150	130.7099
~~40129.94934470~~	1.32955171	.1814073	32.9111	265.2801	114.3325	73.8439
40139.91811960	1.32954388	.1816846	32.9129	314.9843	81.3296	31.6161
40149.97847740	1.32953685	.1820039	32.9093	5.0124	48.0291	356.5899
40159.94874140	1.32952657	.1821998	32.9049	54.6053	15.0083	321.1218
40169.91663820	1.32951564	.1822811	32.9036	103.9553	342.0094	276.9351
40179.97034550	1.32951248	.1819520	32.9042	153.9346	308.7183	216.5052
40189.93188700	1.32951181	.1816199	32.9083	203.5148	275.7456	146.9966
40199.98538130	1.32950975	.1814744	32.9094	253.6332	242.4671	85.6871
~~40209.95297090~~	1.32950555	.1814389	32.9071	303.2792	209.4723	40.5936

Table 1i (Continued)

TIME (MJD)	A (e.r.)	E	INCL (DEG'S.)	OMEGA (DEG'S.)	NODE (DEG'S.)	MEAN ANOM. (DEG'S.)
40219.92282600	1.32949771	.1815922	32.9018	352.9855	176.4693	4.7787
40229.98270070	1.32949120	.1822046	32.8968	42.9492	143.1469	329.9534
40239.95093940	1.32948646	.1822854	32.8962	92.4763	110.1387	288.4393
40249.91550990	1.32948184	.1822691	32.9022	141.9785	77.1431	232.4247
40259.96659390	1.32947276	.1817021	32.9096	191.9121	43.8535	163.1263
40269.92899370	1.32946530	.1813535	32.9174	241.5221	10.8745	98.9971
40279.98498960	1.32945305	.1813594	32.9185	291.6305	337.5842	50.0341
40289.95385640	1.32943978	.1813985	32.9131	341.3060	304.5873	12.8007
40299.92334450	1.32942502	.1817702	32.9011	30.9022	271.5838	338.6579
40309.98110740	1.32939626	.1819426	32.8971	80.8427	238.2746	299.2301
40319.94551640	1.32937277	.1817796	32.8980	130.2429	205.2587	247.1594
40329.99574170	1.32935164	.1815005	32.9000	180.2971	171.9882	179.5780
40339.95604210	1.32933429	.1810957	32.9034	229.9329	139.0058	112.6976
40349.91981980	1.32932034	.1809702	32.9047	279.5673	105.9988	60.5063
40359.97645070	1.32929573	.1811401	32.9044	329.7491	72.6954	20.9087
40369.94424020	1.32927263	.1813848	32.9022	19.4328	39.6983	346.6877
40379.91103640	1.32925145	.1816864	32.8978	68.9322	6.6867	309.5271
40389.96441000	1.32921199	.1816232	32.8990	118.8207	333.3826	260.6427
40399.92373870	1.32918681	.1813464	32.9053	168.3446	300.4039	196.5020
40409.97141840	1.32916487	.1810805	32.9089	218.4068	267.1144	127.1820
40419.93232160	1.32914580	.1808911	32.9088	268.1109	234.1263	71.1540
40429.98643740	1.32913491	.1807369	32.9065	318.2196	200.8167	29.2757
40439.95235660	1.32911292	.1812979	32.9018	7.9107	167.7927	354.6064
40449.91764060	1.32908604	.1816675	32.8984	57.5365	134.7828	318.7833
40459.97008760	1.32906629	.1817372	32.8965	107.3758	101.4637	273.2745
40469.92855250	1.32902910	.1815767	32.9047	156.9149	68.4631	212.4125
40479.97419370	1.32899910	.1810119	32.9133	206.9957	35.1642	142.2955
40489.93225930	1.32896817	.1807744	32.9219	256.5915	2.1792	82.6742
40499.98354920	1.32893853	.1809830	32.9187	306.7581	328.8666	37.9163
40509.94701120	1.32891549	.1814357	32.9130	356.4496	295.8382	2.4183
40519.91035440	1.32888711	.1816994	32.9042	46.0570	262.8113	327.6067
40529.96117170	1.32885619	.1818946	32.9002	95.9863	229.4962	284.9668
40539.91828260	1.32883878	.1815946	32.9018	145.4427	196.4584	227.8423
40549.96192540	1.32881907	.1813061	32.9093	195.4853	163.1659	158.1285
40559.91712460	1.32879627	.1810248	32.9154	245.1233	130.1595	94.9757
40569.96575340	1.32878142	.1809497	32.9179	295.3134	96.8323	47.0265
40579.92719870	1.32876853	.1812091	32.9163	345.0503	63.8030	10.2209

Measurement Residuals (rms)

A (e.r.)	E	INCL (DEG'S.)	OMEGA (DEG'S.)	NODE (DEG'S.)	MEAN ANOM. (DEG'S.)
0.17100-04	0.1920D-03	0.1260D-02	0.6580D-01	0.4080D-01	0.2260D+01

Table 1j
Observations – ARC 10
(Vanguard 3 Rocket From Special NAVSPASUR Tracking)

TIME (MJD)	A (e.r.)	E	INCL (DEG'S.)	OMEGA (DEG'S.)	NODE (DEG'S.)	MEAN ANOM. (DEG'S.)
39129.95302930	1.33196191	.1880559	33.3507 X	225.9446	235.6992	116.9176
39139.94633410	1.33195953	.1877994	33.3471	274.9376	202.8070	63.9652
39149.94306720	1.33195811	.1879312	33.3450	324.0147	169.9345	24.6532
39159.94124500	1.33195809	.1881147	33.3405	13.0892	137.0507	351.1966
39169.93892560	1.33195716	.1887162	33.3409 X	61.9817	104.1703	315.8563
39179.93401770	1.33195553	.1889729	33.3373	110.9954	71.2806	270.2269
39189.92512180	1.33195695	.1886807	33.3413	159.7832	38.4082	208.8332
39199.91431500	1.33195946	.1879150	33.3480	208.6797	5.5403	139.5347
39209.99616910	1.33195704	.1879758	33.3510	258.0543	332.3996	80.3230
39219.99137760	1.33195515	.1877276	33.3461	307.0610	299.5302	37.1636
39229.98974340	1.33195222	.1879883	33.3421	356.2547	266.6333	2.5136
39239.98775670	1.33195314	.1886884	33.3352	45.1316	233.7382	328.7635
39249.98392980	1.33195162	.1888803	33.3337	94.0385	200.8607	287.6797
39259.97635210	1.33194784	.1888384	33.3343	142.9293	167.9781	231.7587
39269.96552240	1.33194545	.1885709	33.3394	191.8394	135.0984	163.0129
39279.95590890	1.33194563	.1880492	33.3464	240.7292	102.2412	99.1429
39289.95025230	1.33194524	.1877157	33.3482	289.7037	69.3799	51.0357
39299.94748720	1.33194332	.1878741	33.3456	338.8542	36.4986	14.2936
39309.94553420	1.33193883	.1882637	33.3420	27.9648	3.6016	341.0123
39319.94242510	1.33193710	.1885880	33.3364	76.8080	330.7185	303.4931
39329.93615970	1.33193429	.1885786	33.3366	125.6130	297.8396	253.4815
39339.92594930	1.33192563	.1883477	33.3398	174.5260	264.9743	187.8715
39349.91509160	1.33191797	.1878964	33.3453	223.4425	232.1000	120.0931
39359.99773750	1.33191628	.1877241	33.3474	272.8454	198.9512	65.9055
39369.99384780	1.33190871	.1875520	33.3450	321.9768	166.0661	26.1334
39379.99139410	1.33189992	.1878366	33.3388	11.0451	133.1749	352.5724
39389.98842470	1.33188835	.1885495	33.3328	59.8018	100.2900	317.5729
39399.98282460	1.33187600	.1884193	33.3359	108.7837	67.4049	272.5538
39409.97314080	1.33186524	.1881773	33.3403	157.6910	34.5349	211.7229
39419.96115500	1.33184518	.1879253	33.3478	206.6001	1.6803	142.3714
39429.95142450	1.33182768	.1876939	33.3518	255.5102	328.8310	82.9878
39449.94137010	1.33177832	.1875852	33.3443	353.7645	263.0689	4.1905
39459.93732810	1.33175731	.1881611	33.3346	42.7538	230.1843	330.4748
39469.93133430	1.33173745	.1883802	33.3299	91.4997	197.2800	290.0710
39479.92143940	1.33171204	.1880337	33.3344	140.3419	164.3848	235.0628
39489.99792800	1.33169190	.1876836	33.3409	189.7853	131.2149	165.9686
39519.96934490	1.33159488	.1878196	33.3525 X	337.0615	32.5753	15.5268
39529.96316060	1.33153945	.1881108	33.3443	26.0396	359.6906	342.3429
39539.95539950	1.33150111	.1884853	33.3374	74.8841	326.7958	305.1471
39549.94421710	1.33146994	.1884054	33.3360	123.7252	293.9066	255.7062
39559.92868430	1.33142278	.1878061	33.3377	172.6269	260.9959	190.5853
39569.91189600	1.33137787	.1872759	33.3446	221.7355	228.1127	122.3310
39579.98799450	1.33133268	.1875279	33.3504	271.1799	194.9333	67.4848
39589.97725040	1.33129984	.1875319	33.3489	320.2705	162.0346	27.3651
39599.96784580	1.33127890	.1881544	33.3417	9.3115	129.1031	353.7464
39609.95782510	1.33125490	.1883555	33.3345	58.2876	96.1938	318.7477
39619.94514400	1.33123245	.1883329	33.3347	107.1223	63.2999	274.3174
39629.92831250	1.33121551	.1880150	33.3426	155.9895	30.3774	214.0717
39639.99888190	1.33118581	.1873689	33.3496	205.4662	357.1929	143.9633
39649.98163200	1.33117014	.1873948	33.3548	254.5466	324.3072	84.0310

Table 1j (Continued)

TIME (MJD)	A (e.r.)	E	INCL (DEG'S.)	OMEGA (DEG'S.)	NODE (DEG'S.)	MEAN ANOM. (DEG'S.)
39659.96821620	1.33116446	.1874672	33.3547	303.6306	291.4130	39.8282
39669.95705800	1.33115922	.1878311	33.3445	352.6892	258.4996	4.9112
39679.94613790	1.33115492	.1881552	33.3355	41.6971	225.6037	331.2452
39689.93348830	1.33115022	.1883792	33.3319	90.5884	192.6837	290.9397
39699.91714740	1.33113915	.1882122	33.3387	139.4328	159.7551	236.2550
39709.98719090	1.33112589	.1878836	33.3475	188.8324	126.5777	167.3254
39719.96810160	1.33111676	.1873843	33.3545	237.8634	93.6856	102.5403
39729.95284980	1.33110992	.1873886	33.3551	286.9925	60.7823	53.3575
39739.94050490	1.33110163	.1876391	33.3530	336.1009	27.8665	16.1952
~~39749.92905520~~	1.33109590	.1880510	33.3479	25.1360	354.9672	342.9662
39759.91652110	1.33108614	.1883145	33.3415	74.0919	322.0607	305.8096
39769.99074550	1.33107258	.1882924	33.3420	123.3357	288.8316	256.1532
39779.97093140	1.33105672	.1879113	33.3486	172.2466	255.9371	191.1318
39789.95016440	1.33104345	.1878056	33.3546	221.2667	223.0457	122.8826
39799.93267250	1.33102975	.1874650	33.3554	270.3720	190.1401	68.2533
39809.91863270	1.33102173	.1872684	33.3522	319.4463	157.2380	27.9783
39819.99614590	1.33101264	.1881291	33.3461	8.9605	124.0159	353.9822
~~39829.98321250~~	1.33100365	.1883842	33.3406	57.9137	91.0953	319.0430
39839.96781590	1.33099487	.1883611	33.3415	106.8062	58.1723	274.6560
39849.94831890	1.33097628	.1882004	33.3509	155.7004	25.2507	214.4824
39849.94831890	1.33097627	.1882005	33.3510	155.7004	25.2507	214.4824
39859.92631840	1.33095751	.1878768	33.3595	204.6431	352.3700	145.0641
39869.99637150	1.33093463	.1873288	33.3619	254.2347	319.1638	84.3665
39879.98020000	1.33091455	.1872796	33.3610	303.3206	286.2658	40.0845
39889.96609700	1.33088391	.1874449	33.3530	352.4160	253.3497	5.0996
~~39899.95192410~~	1.33085546	.1879931	33.3400	41.3496	220.4245	331.4880
39909.93584400	1.33083788	.1881803	33.3402	90.2364	187.4809	291.2516
39919.91601050	1.33085245X	.1879371	33.3444	139.1626	154.5764	236.5777
39949.93964330	1.33072090	.1868905	33.3628	286.7857	55.5596	53.5834
39959.92277280	1.33069030	.1871020	33.3585	335.8343	22.6543	16.3989
39969.99646320	1.33065794	.1874570	33.3518	25.3253	349.4369	342.8123
39979.97884960	1.33062603	.1877289	33.3463	74.2569	316.5059	305.6092
39989.95782560	1.33059256	.1877165	33.3466	123.1549	283.5925	256.3023
~~39999.93255330~~	1.33056155	.1873110	33.3515	172.0782	250.6785	191.3601
40009.99599390	1.33053158	.1870606	33.3530	221.5555	217.4925	122.5817
40019.97270930	1.33050684	.1868454	33.3514	270.6922	184.5757	68.0206
40029.95269680	1.33048220	.1869292	33.3507	319.8285	151.6485	27.7210
40039.93404100	1.33045795	.1872383	33.3463	8.9269	118.7046	353.9930
40049.91479530	1.33043755	.1876841	33.3422	57.9107	85.7661	318.9874
40059.98280240	1.33041252	.1876772	33.3416	107.2285	52.5424	274.1276
40069.95667270	1.33038630	.1874264	33.3496	156.1694	19.6212	213.7871
40079.92799990	1.33035720	.1869304	33.3561	205.1951	346.7166	144.3641
40089.99118720	1.33032437	.1868925	33.3593	254.7199	313.5146	83.9081
40099.96815370	1.33030269	.1869279	33.3560	303.8357	280.5796	39.7123
40109.94714490	1.33026948	.1872124	33.3508	352.9773	247.6285	4.7240
40119.92597940	1.33022874	.1877248	33.3438	42.0060	214.6804	330.9934
40129.99256070	1.33019271	.1879124	33.3420	91.3856	181.4408	290.1270
40139.96520720	1.33015550	.1876883	33.3453	140.3084	148.5051	235.0748
40149.93410810	1.33011403	.1872139	33.3536	189.2965	115.5775	166.6786
~~40159.99324280~~	1.33005892	.1870215	33.3603	238.8120	82.3528	101.4749
40169.96588820	1.33001307	.1869979	33.3643	287.9481	49.4213	52.5845
~~40179.94109080~~	1.32998351	.1872741	33.3631	337.0769	16.4721	15.5352
40189.91691340	1.32995879	.1874488	33.3588	26.1595	343.5230	342.2338
40199.98128040	1.32993658	.1877134	33.3540	75.5853	310.2753	304.4640
40209.95248650	1.32992001	.1876984	33.3539	124.4936	277.3287	254.7182
40219.91960000	1.32989680	.1873561	33.3592	173.4429	244.4034	189.4086
40229.97559630	1.32987553	.1868271	33.3625	222.9686	211.1664	120.7987
40239.94506690	1.32985865	.1867793	33.3650	272.0714	178.2278	66.7325
40249.91789140	1.32984478	.1869035	33.3656	321.2070	145.2881	26.7252
~~40259.98198420~~	1.32982777	.1873050	33.3614	10.7267	112.0289	352.7788
40269.95560910	1.32981207	.1875787	33.3592	59.7202	79.0746	317.5548
40279.92661120	1.32979281	.1875885	33.3625	108.6785	46.1288	272.5692
40289.98318620	1.32976958	.1872606	33.3666	158.0537	12.8843	211.1531
40299.94760050	1.32974237	.1868719	33.3729	207.1048	339.9609	141.7523
40309.91416090	1.32971143	.1867003	33.3742	256.1946	307.0346	82.3919
40319.97418090	1.32969391	.1867321	33.3715	305.7685	273.7857	38.2325
40329.94644890	1.32967981	.1871385	33.3667	354.8634	240.8246	3.4546
~~40339.91877890~~	1.32966774	.1874777	33.3603	43.8974	207.8683	329.5928
40349.97901630	1.32965779	.1875991	33.3563	93.2940	174.6089	288.2554
40359.94561920	1.32964247	.1873440	33.3587	142.1874	141.6567	232.5996
40369.99862840	1.32963426	.1867666	33.3654	191.6370	108.4112	163.3571
40379.96296690	1.32963000	.1867852	33.3708	240.7401	75.4870	99.2741
40389.93117470	1.32962074	.1867070	33.3746	289.8368	42.5424	51.0217
40399.99201750	1.32961716	.1869393	33.3709	339.4226	9.2941	13.9330
40409.96383690	1.32961326	.1872630	33.3628	28.5339	336.3165	340.5729
~~40419.93445250~~	1.32960602	.1875421	33.3577	77.4007	303.3556	302.8683
40429.99163180	1.32960313	.1874532	33.3578	126.8444	270.1146	251.8820
40439.95515200	1.32959796	.1868984	33.3604	175.7914	237.1598	186.0371
40449.91817210	1.32959300	.1867071	33.3640	224.8875	204.2290	118.3810
40459.97452560	1.32958891	.1865672	33.3660	274.5152	170.9817	64.4884
40459.97452570	1.32958892	.1865685	33.3660	274.5153	170.9821	64.4883
40469.94444000	1.32957505	.1866415	33.3638	323.6215	138.0307	25.0039
40479.91565690	1.32956001	.1867936	33.3591	12.7711	105.0768	351.3861
40479.91565830	1.32955960	.1868755	33.3594	12.7744	105.0716	351.3855
40489.97600720	1.32953959	.1873416	33.3567	62.1964	71.7983	315.5638
40499.94371160	1.32951410	.1873393	33.3597	111.1162	38.8391	269.9042
40509.99693550	1.32949072	.1869810	33.3672	160.5090	5.6024	207.7299
40519.95823660	1.32946071	.1865645	33.3755	209.5540	332.6770	138.4465
40529.92182100	1.32942382	.1862241	33.3768	258.7221	299.7316	79.8447
40539.97866660	1.32939125	.1862757	33.3756	308.3347	266.4850	36.3021
40549.94745710	1.32935214	.1865293	33.3680	357.4371	233.5175	1.7257
~~40559.91585120~~	1.32930844	.1868057	33.3567	46.5298	200.5532	327.6017
40569.97174160	1.32928094	.1870646	33.3533	95.8751	167.2871	285.6733
40579.93378850	1.32924707	.1869565	33.3576	144.8486	134.3307	229.0693
40589.98204690	1.32920511	.1870398X	33.3658	194.3716	101.0853	159.4698

Measurement Residuals (rms)

A (e.r.)	E	INCL (DEG'S.)	OMEGA (DEG'S.)	NODE (DEG'S.)	MEAN ANOM. (DEG'S.)
0.11800-04	0.21600-03	0.12500-02	0.12300-00	0.69500-01	0.23100+0'

Table 2
Observability of Resonant Frequencies for Vanguard 3
[(m = 11) - Amplitude of Inclination Variation Estimated by Kaula's Rule: 10^{-4} Deg's.]

q → Period (days) →	-3 60.43	-2 340.71	-1 93.65	0 41.17	1 26.38	2 19.41	3 15.35
ℓ = 11		1.70		.192		.003	
12	.316		1.63		.103		–
13		7.74		.997		.032	
14	.797		4.60		.407		.007
15		14.4		2.29		.119	
16	.990		7.28		.918		.027
17		16.1		3.44		.283	
18	.644		7.76		1.45		.071
19		10.9		3.73		.487	
20	.045		5.62		1.70		.135
21		2.91		2.94		.636	
22	.325		2.23		1.50		.198
23		2.70		1.50		.639	
24	.280		.443		.935		.226
25		3.58		.16		.474	
26	.025		1.37		.282		.197
27		1.37		.518		.217	
28	.142		.874		.161		.119
29		.828		.504		.010	
30	.114		.004		.275		.027
31		1.31		.157		.118	
32	.003		.433		.156		.036
33		.484		.126		.103	
34	.069		.316		.009		.050
1 RSS →	1.536	26.11	13.30	6.597	3.056	1.205	.4175
2 $\frac{\text{RSS} \times 100^{d}}{\text{Period}}$	2.542	7.663	14.202	16.02	11.58	6.208	2.720
* 3 Resonance Time (Days)	208	759	398	329	256	516	750(?)
4 $\frac{2 \times 3}{1000}$:	.529	5.816	5.652	5.271	2.962	3.203	2.04
5 4/5.816: (Estimate of relative commensurable effect using Kaula's Rule)	.091	1.000	.972	.906	.510	.551	.351(?)
6 Observed 'I' variation through commensurability: 10^{-3} deg's.	1.0	18.0	11.5	19.5	11.0	5.5	1.9(?)
7 6/18.0	.06	1.000	.64	1.08	.61	.31	.35(?)
8 Kaula Amp./obs. amp.**	5.63	1.56	2.44	1.18	1.31	1.79	
9 4/8	.0940	3.73	2.32	4.47	2.26	1.79	
10 9/3.73 Estimate of effect with observed lumped harmonics	.03	1.00	.62	1.20	.61	.48	

RSS = Root sum of squares
*Time ψ spends within 180° of commensurability
** From Table 5; Kaula Amp. = Estimate of amplitude of lumped harmonic from Kaula's Rule.
Obs. Amp. = Observed Amplitude

Table 3

Results of Vanguard Multi-Arc Orbit and Field Determinations

Run #	Field Used: Resonant (m,q) Determined**	Inclination Residuals (rms) (10^{-3} Degrees) Arcs:*										Comments
		1	2	3	4	5	6	7	8	9	10	
1	Nonresonant	2.78	3.46	4.95	4.22	1.30	4.34	6.97	2.14	4.61	9.55	Uses 5 secular 'M' rates in each arc
2	(11,-2),(11,-1),(11,0) (11,1)	.75	.75	1.85	1.61	1.12	2.01	1.52	1.79	1.96	1.49	Poor fit to 'a' and 'M' in some arcs
3	(11,-2),(11,-1),(11,0) (11,1)	.75	.73	1.83	1.61	1.12	1.38	1.29	1.76	1.43	1.26	Uses 4 'a' rates and 7 'M' rates in some arcs. Poor obs. edited in arc 6 prior to 39075 MJD
4	(11,-2),(11,-1),(11,0) (11,1),(11,2)	.75	.72	1.84	1.57	.80	1.38	1.27	.97	1.43	1.26	ℓ,m=3,0 Solve (reasonable) Maximum ΔM=25° (rms)
5	(11,-2),(11,-1),(11,0) (11,1),(11,2),(22,0)	.75	.72	1.79	1.56	.79	1.37	1.28	.97	1.44	1.25	—
6	Same as Run 5 Plus (22,-1),(22,1)	.74	.72	1.67	1.54	.79	1.38	1.27	.97	1.26	1.24	Some moderate cross correlations with m = 22
7	Same as Run 6 Plus (11,-3)	.74	.72	1.66	1.54	.79	1.38	1.27	.97	1.26	1.25	—
8	Same as Run 7	← Same as Run 7 →										Uses I data only

*Arc 1, 1960-1961 Vanguard 3 mean elements from precise Baker-Nunn data
Arc 2, 1961-1964 Vanguard 3 mean elements from precise Baker-Nunn data
Arc 3, 1966-1968 Vanguard 2 rocket routine mean elements from NAVSPASUR radio Interferometer data
Arc 4, 1968-1971 Vanguard 2 rocket routine mean elements from NAVSPASUR radio Interferometer data
Arc 5, 1971-1973 Vanguard 2 rocket routine mean elements from NAVSPASUR radio Interferometer data
Arc 6, 1966-1968 Vanguard 3 routine mean elements from NAVSPASUR radio Interferometer data
Arc 7, 1968-1970 Vanguard 3 routine mean elements from NAVSPASUR radio Interferometer data
Arc 8, 1970-1973 Vanguard 3 routine mean elements from NAVSPASUR radio Interferometer data
Arc 9, 1966-1969 Vanguard 2 rocket special mean elements from NAVSPASUR Interferometer data
Arc 10, 1966-1969 Vanguard 3 rocket special mean elements from NAVSPASUR Interferometer data
**For results, see Figure 4.

Table 4

Influence Coefficients (Q) for Vanguard Resonances*

m = 11 q	$\ell = 11$	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
-3		.180		-.616		1.000		-.823		.071		.620		-.636		.066		.439		-.405		-.013		.313		-.227		-.062
-2	-.044		.282		-.699		1.000		-.852		.276		.308		-.482		.215		.150		-.272		.114		.100		-.155	
-1		-.094		.358		-.741		1.000		-.893		.430		.101		-.368		.272		-.001		-.176		.145		-.014		-.085
0	.017		-.125		.381		-.735		1.000		-.972		.610		-.105		-.256		.311		-.127		-.082		.150		-.072	
+1		-.020		.109		-.319		.636		-.927		1.000		-.755		.292		.142		-.325		.227		-.005		-.140		.125
+2	.001		-.016		.078		-.239		.514		-.824		1.000		-.891		.499		-.012		-.310		.330		-.124		-.100	

m = 22 q =	$\ell = 22$	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
-1		$-.127^{-2}$		.010		-.045		.137		-.315		.573		-.842		1.000		-.933		.623		-.186		-.1[illegible]5		.334		-.241	
0	$.134^{-3}$		$-.199^{-2}$		.012		-.048		.136		-.305		.551		-.819		1.000		-.985		.733		-.323		-.076		.299		-.285
1		$-.239^{-3}$		$.228^{-2}$		-.012		.044		-.123		.272		-.498		.756		-.960		1.000		-.818		.454		-.046		-.240	

*Using the orbit of Vanguard 3 for (m,q) = (11,-3), (11,-2), and the average of the Vanguard 2R & 3 orbits for the others

Table 5
Lumped Harmonics (C*, S*) for Vanguard Resonances
(Units: 10^{-9})

(m,q)	Observed† (Best Results)	PGS-162 (19)††	PGS 63 (25)	SAO 1969 B6.1 (16)	SAO SE 3 (18)	WGS-72 (19)	Estimate of Effect on C*, S* of all Terms $\geq \ell$ (Using Kaula's Rule & rss of Terms)											
							$\ell = 11$	17	19	21	23	25	27	29	31	33	35	37
(11,-3)	$15.0^{9.0}, -2.4^{16.8}$	28.8,25.4	7.7,15.9	0.1,-19.4	-93.7,3.2	39.6,0.4	60.6	31.6	18.9	18.8	13.7	8.0	7.9	5.6	3.4	3.4	1.9	.6
(11,-2)	$-38.1^{1.0}, -33.4^{1.2}$	-45.2,-46.1	-49.7,-39.1	-25.7,-57.6	-32.0,3.0	-32.2,-56.6	56.3	43.7	26.7	12.4	10.7	9.0	4.7	3.8	3.4	1.9	1.6	1.4
(11,-1)	$-30.6^{1.0}, 0.3^{2.1}$	-35.1,-18.3	-37.0,-14.6	-17.2,-10.3	70.7,5.0	-36.7,14.0	52.9	39.8	25.1	11.4	7.1	6.9	4.3	2.3	2.3	1.5	.8	.8
(11,0)	$26.1^{2.2}, 52.6^{1.1}$	42.3,38.4	32.3,52.5	11.9,31.9	23.7,-0.3	18.1,61.2	49.1	45.4	37.7	25.5	12.9	5.7	5.4	4.2	2.1	1.6	1.4	.7
(11,1)	$-42.9^{1.5}, -13.9^{2.9}$	-22.2,-7.9	-36.9,-10.3	-15.4,-15.9	31.7,6.0	-19.6,9.7	41.9	39.6	34.4	25.4	14.6	6.4	4.8	4.4	2.5	1.5	1.5	1.1
(11,2)	$13.6^{1.5}, 24.5^{1.4}$	19.3,14.5	9.4,19.8	1.7,6.7	8.0,0.5	3.7,29.8	35.5	35.3	34.4	31.3	25.2	16.5	8.3	4.7	4.7	3.4	1.4	1.0
							$\ell = 22$	33	35	37	39	41	43	45	47	49		
(22,-1)	$-16.5^{5.1}, -29.2^{8.0}$						14.2	13.6	12.6	10.5	7.6	4.6	2.5	2.3	2.1	1.4		
(22,0)	$-27.9^{6.2}, 29.5^{12.7}$						13.6	13.2	12.3	10.5	7.9	4.9	2.7	2.1	2.1	1.6		
(22,1)	$-16.0^{7.0}, 20.5^{10.8}$						12.6	12.5	12.2	11.5	10.1	7.9	5.2	2.7	1.4	1.4		

†Run 8, Table 3.
The Superscripts are standard deviations.
For the full correlation matrix of the solution, see Table 6
††Max. Degree, 11th Order

Table 6
Correlation Coefficients of Vanguard Resonance Solutions
(For Lumped Coefficients)

Coeff. # → i	(m,q)	Standard Deviations on the Diagonal: Units, 10^{-9} (for PGS: $\kappa = 1$)																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	(11,-3)C*	14.1/9.0	.02	-.03	-.12	-.84	-.05	-.10	.05	-.63	-.05	-.17	-.02						
2	(11,-3)S*	-.30	13.1/16.8	.04	-.04	-.00	-.81	.06	-.05	.01	-.55	.11	-.11						
3	(11,-2)C*	-.20	-.23	15.0/1.0	-.03	.10	-.02	-.79	-.00	.13	-.01	-.43	-.03						
4	(11,-2)S*	.11	.20	-.46	17.5/1.0	.14	.14	.03	-.84	.12	.18	.02	-.55						
5	(11,-1)C*	-.01	.00	-.08	.06	14.3/1.0	.02	.03	-.07	.95	.03	.12	-.00						
6	(11,-1)S*	-.03	.05	-.13	.10	.71	12.6/2.1	-.09	-.05	.01	.94	-.15	.03						
7	(11,0)C*	.02	.02	.07	-.09	-.02	-.18	13.1/2.2	.00	-.01	-.09	.89	.03						
8	(11,0)S*	-.01	-.02	-.03	.08	-.08	.10	-.38	15.7/1.1	-.07	-.10	.00	.91						
9	(11,1)C*	-.00	.01	-.02	.01	-.01	-.02	-.02	.04	9.5/1.5	.02	.08	-.01						
10	(11,1)S*	-.01	-.00	.04	-.02	.00	.05	-.16	.18	-.22	8.5/2.9	-.15	-.02						
11	(11,2)C*	.00	-.01	-.02	.01	.01	.02	-.02	.02	-.03	-.05	7.2/1.5	.02						
12	(11,2)S*	.00	-.00	-.01	.01	.00	-.00	.01	.00	.02	-.05	.71	8.2/1.4						
13	(22,-1)C*	-.00	.01	-.02	.01	.03	-.04	-.13	.18	-.02	-.02	.01	.01	14.2/5.1	.00	.00	.00	.84	.00
14	(22,-1)S*	.00	.01	-.01	.00	-.33	-.13	-.06	.34	.05	.04	-.01	-.01	-.51	14.2/8.0	.00	.00	.00	.84
15	(22,0)C*	.01	.00	.01	-.03	-.07	-.06	.45	.23	-.02	-.03	.01	.02	.16	-.18	13.6/6.2	.00	.00	.00
16	(22,0)S*	.00	-.00	.03	-.04	.05	.03	-.19	-.32	.06	-.00	-.02	-.01	.23	-.02	-.52	13.6/23.7	.00	.00
17	(22,1)C*	.01	.01	-.00	-.01	-.08	-.13	.03	-.07	-.06	-.01	-.01	.00	-.09	.00	-.06	.12	12.6/7.0	.00
18	(22,1)S*	-.01	.00	.04	-.05	-.01	-.01	-.07	.02	.15	.18	-.01	.00	.04	.01	.22	.11	-.52	12.6/10.0

Lower Diagonal Matrix: This Solution (Best results)
Upper Diagonal Matrix: PGS 162
22nd Order Terms: Using Kaula's Rule)

Table 6a
Full Residual Error Correlation Matrix for 11th and 22nd Order Terms with PGS 162

Coeff. # → i	(m,q)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	(11,-3)C*	(279)	-.11	-.03	-.10	-.71	-.04	-.08	.04	-.53	-.04	-.14	-.02	-.00	.00	.01	.00	.01	-.01
2	(11,-3)S*		(454)	.01	-.02	.00	-.48	.04	-.03	.01	-.32	.06	-.07	.01	.01	.00	-.00	.01	.00
3	(11,-2)C*			(228)	-.03	.10	-.02	-.77	-.00	.13	-.01	-.42	-.03	-.02	-.01	.01	.03	-.00	.04
4	(11,-2)S*				(306)	.14	.14	.03	-.84	.12	.17	.02	-.54	.01	.00	-.03	-.04	-.01	-.05
5	(11,-1)C*					(204)	.03	.03	-.07	.94	.03	.12	.00	.03	-.33	-.07	.05	-.08	-.01
6	(11,-1)S*						(164)	-.09	-.05	.01	.88	-.14	.03	-.04	-.13	-.06	.03	-.13	-.01
7	(11,0)C*							(176)	-.00	-.01	-.09	-.86	.03	-.13	-.06	.45	-.19	.03	-.07
8	(11,0)S*								(246)	-.07	-.09	.00	.90	.18	.34	.23	-.32	-.07	.02
9	(11,1)C*									(92.2)	.01	.08	-.01	-.02	.05	-.02	.06	-.06	.15
10	(11,1)S*										(80.4)	-.14	-.02	-.02	.04	-.03	-.00	-.01	.18
11	(11,2)C*											(54.2)	.04	.01	-.01	.01	-.02	-.01	-.01
12	(11,2)S*												(69.0)	.01	-.01	.02	-.01	.00	.00
13	(22,-1)C*													(228)	-.08	.02	.05	.68	.01
14	(22,-1)S*														(266)	-.04	-.01	.00	.58
15	(22,0)C*															(223)	.15	-.01	.06
16	(22,0)S*																(346)	.04	.05
17	(22,1)C*																	(208)	-.16
18	(22,1)S*																		(259)

Diagonal Terms $= E(O-C)_i^2$: units $= 10^{-18}$

Off Diagonal Terms $= \dfrac{E(O-C)_i\ (O-C)_j}{[E(O-C)_i^2\ E(O-C)_j^2]^{1/2}}$

$\Delta T = 0,\ \kappa = 1$, for 11th Order Terms

$\delta^2\ T_{ii}$ and $\delta^2\ T_{ij}$ Estimated from Kaula's Rule for 22nd Order Terms (i and j)

Table 7
Analysis of Vanguard Residuals (Lumped Coefficients) Using PGS 162
[Units of 10^{-9}: 10^{-18} Columns 2, 4, 6, 8, 10, 14: 3, 5, 7, 9, 15]

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Coeff. #	(m,q)	(O-C)	$(O-C)^2$	e	e^2	σ Diagonal Terms Only	σ^2	δT (Kaula)	$\delta^2 T$ (Kaula)	$(e^2+\sigma^2)^{1/2}$	Z	χ_1^2 ($\kappa = 1.20$, $\Delta T = 0$)	α	$\delta^2 T$ more realistic estimate	$\delta^2 T$ more realistic	χ_1^2 with $\kappa = 1.05$ and more realistic $\delta^2 T$ estimate
1	(11,-3)C*	-13.8	190.0	9.0	81.0	(25.1) 14.1	198	18.4	339	16.7	- .83	0.64	0.40	.35	.12	.63
2	(11,-3)C*	-27.8	773.0	16.8	282	(24.6) 13.1	172	18.4	339	21.3	-1.30	1.41	0.23	.90	.81	1.64
3	(11,2)C*	+ 6.6	43.0	1.0	1.0	(31.7) 15.0	226	12.7	161	15.1	0.44	0.56	0.65	1.85	3.4	.17
4	(11,-2)S*	+12.7	161.0	1.2	1.4	(32.9) 17.5	305	12.7	161	17.5	0.73	0.41	0.50	3.35	11.2	.46
5	(11,-1)C*	+ 4.5	20.3	1.0	1.0	(24.1) 14.3	204	11.4	130	14.3	0.31	0.048	0.85	3.90	15.2	.084
6	(11,-1)S*	+18.6	346.0	2.1	4.4	(23.1) 12.6	160	11.4	130	12.8	1.45	1.29	0.25	2.60	6.8	1.84
7	(11,0)C*	-16.2	262.0	2.2	4.8	(27.2) 13.1	171	25.5	650	13.3	-1.22	1.16	0.27	6.15	37.8	1.13
8	(11,0)S*	+14.2	202.0	1.1	1.2	(28.4) 15.7	245	25.5	650	15.7	0.90	0.54	0.40	5.15	26.5	.68
9	(11,1)C*	-20.7	428.0	1.5	2.3	(13.8) 9.5	90	25.4	645	9.6	-2.16	3.40	0.07	3.85	14.8	3.68
10	(11,1)S*	- 6.0	36.0	2.9	8.4	(13.1) 8.5	72	25.4	645	9.0	-0.67	0.28	0.60	2.80	7.8	.38
11	(11,2)C*	- 5.7	32.0	1.5	2.3	(11.7) 7.2	52	31.3	980	7.4	-0.77	0.23	0.65	4.45	19.8	.40
12	(11,2)S*	+10.0	100.0	1.4	2.0	(12.3) 8.2	67	31.3	980	8.3	1.20	1.08	0.30	2.25	5.1	1.24
											$\sum_{12} Z = -1.91$	$\hat{K} = 1.2 \pm 0.2$				$\hat{K} = 1.05 \pm 0.15$
											$Z_{12} = \sum_{12} Z/\sqrt{12}$ $= -0.55$ O.K.					